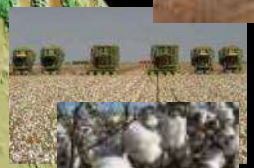
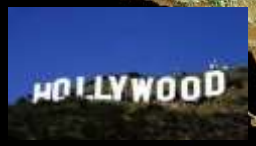
NOAA
FISHERIES
SERVICE

California's water: where do salmon fit in?

SWFSC, WCRO, NWFSC and collaborators

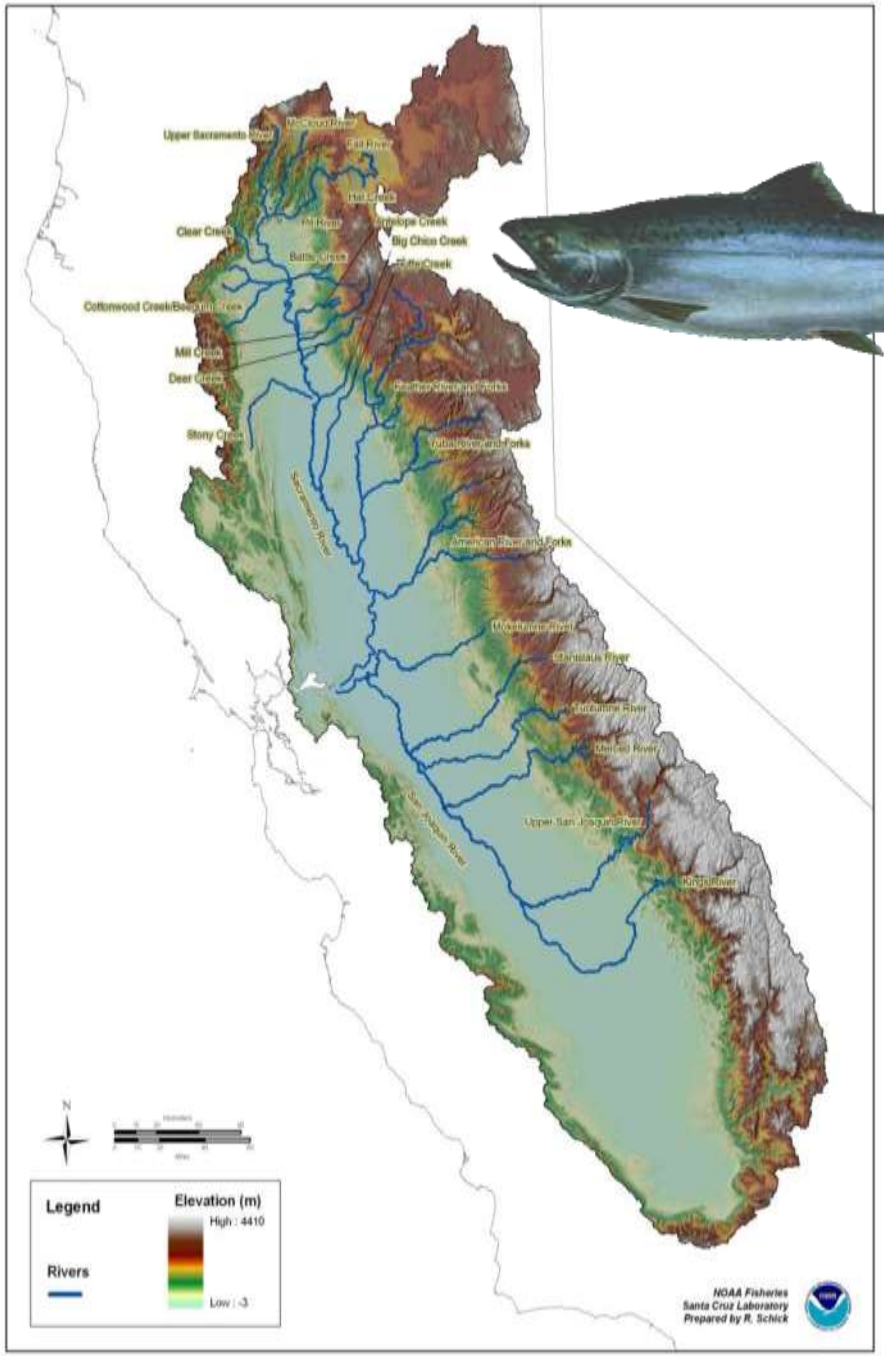
CONGRESS
CREATED
DUST
BOWL




HOLLYWOOD

California
Aquaducts
Shasta Lake
Sacramento River
Oroville Dam
Folsom Dam
Lake Tahoe
Sacramento
Mokelumne Aqueduct
San Francisco
Hetch-Hetchy Aqueduct
San Joaquin R.
Mono Lake
Madera Canal
Fresno
Friant Dam
Friant Kern Canal
Coastal Aqueduct
California Aqueduct
Los Angeles Aqueduct
Owens Lake
Lake Mead
Hoover Dam
Lake Havasu
Parker Dam
Pacific Ocean
Los Angeles
Colorado River Aqueduct
San Diego Aqueduct
Coachella Canal
Salton Sea
Colorado River
San Diego
All American Canal
Imperial Dam
N
W
E
S
© maps.com

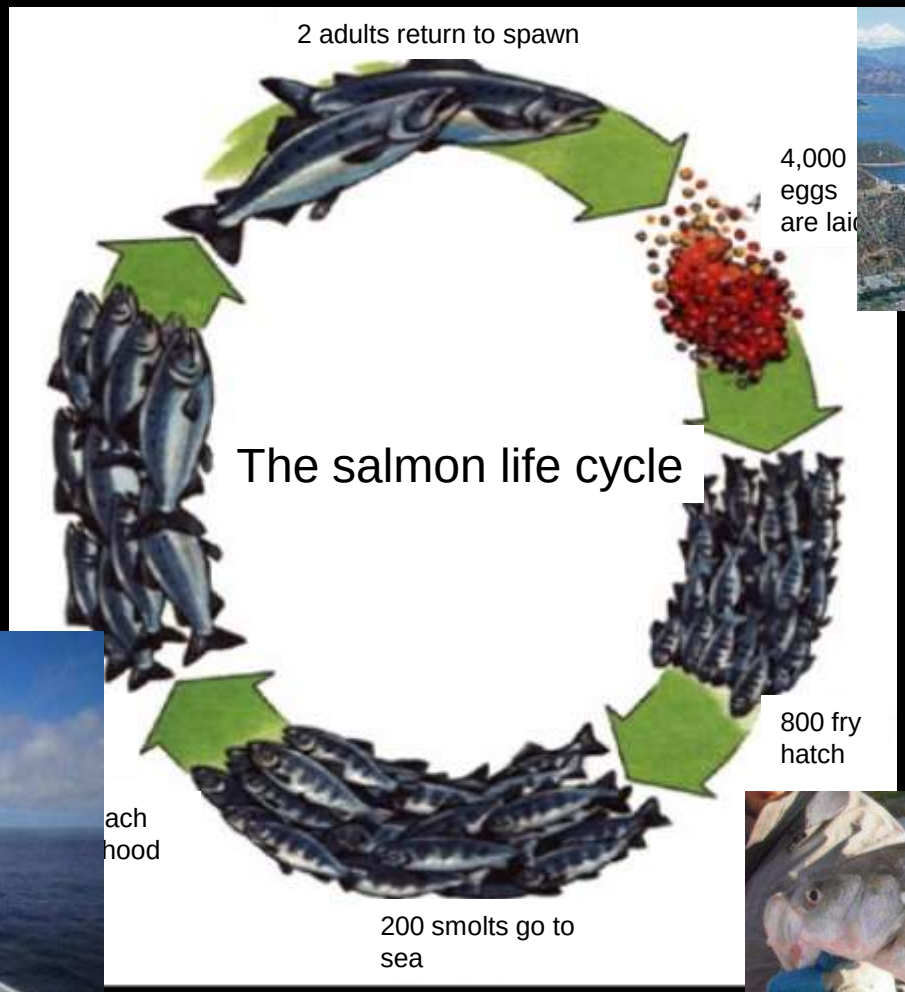
Central Valley Chinook Salmon Life History



	Late-fall	Winter	Spring	Fall
Migration	Oct–Apr	Dec–Jul	Mar–Jul	Jun-Dec
Spawning	Jan–Apr	Apr–Aug	Aug–Oct	Sep-Dec
% 3y/4y	57/41	91/8	87/11	77/20
Emerge	Apr–Jun	Jul–Oct	Nov-Mar	Dec-Mar
Ocean	Dec-Apr	Feb-Apr	Mar-May	Apr-Jun
Size at Ocean Entry	160 mm	110 mm	80 mm	80 mm

Challenges for Salmon in CA

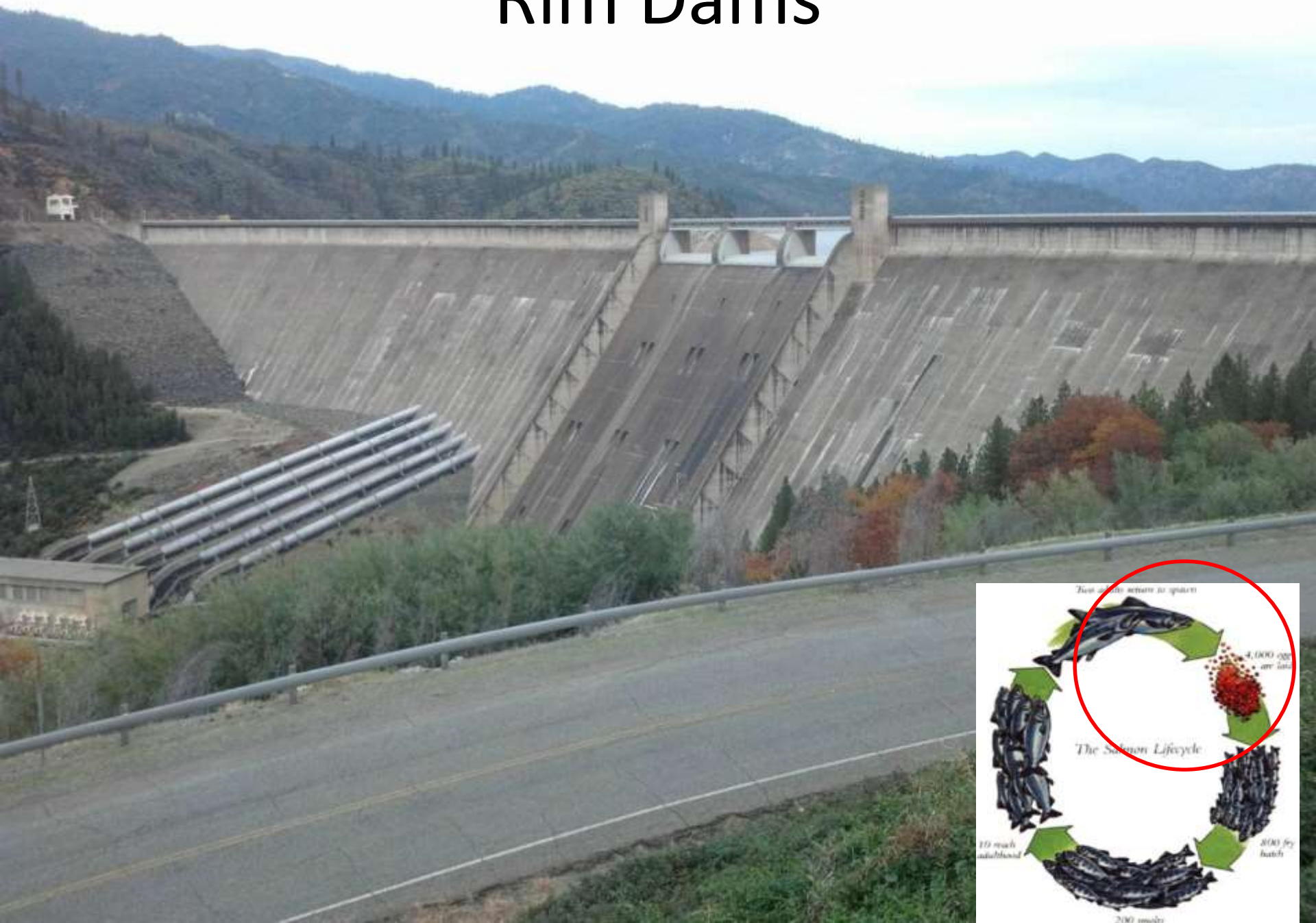
Ocean?



Freshwater?

www.thinksalmon.com

Rim Dams

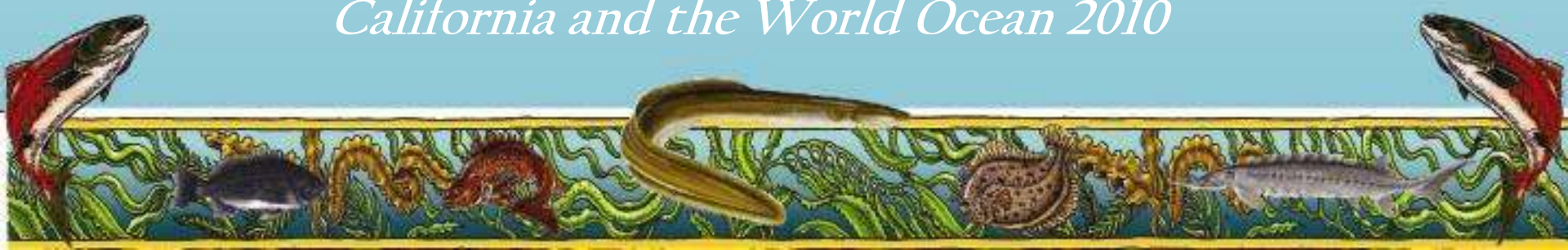


NOAA's National Marine Fisheries Service
Southwest Regional Office- Habitat Conservation Division

Status of Salmon Habitat in California: Hydromodified Chaos.

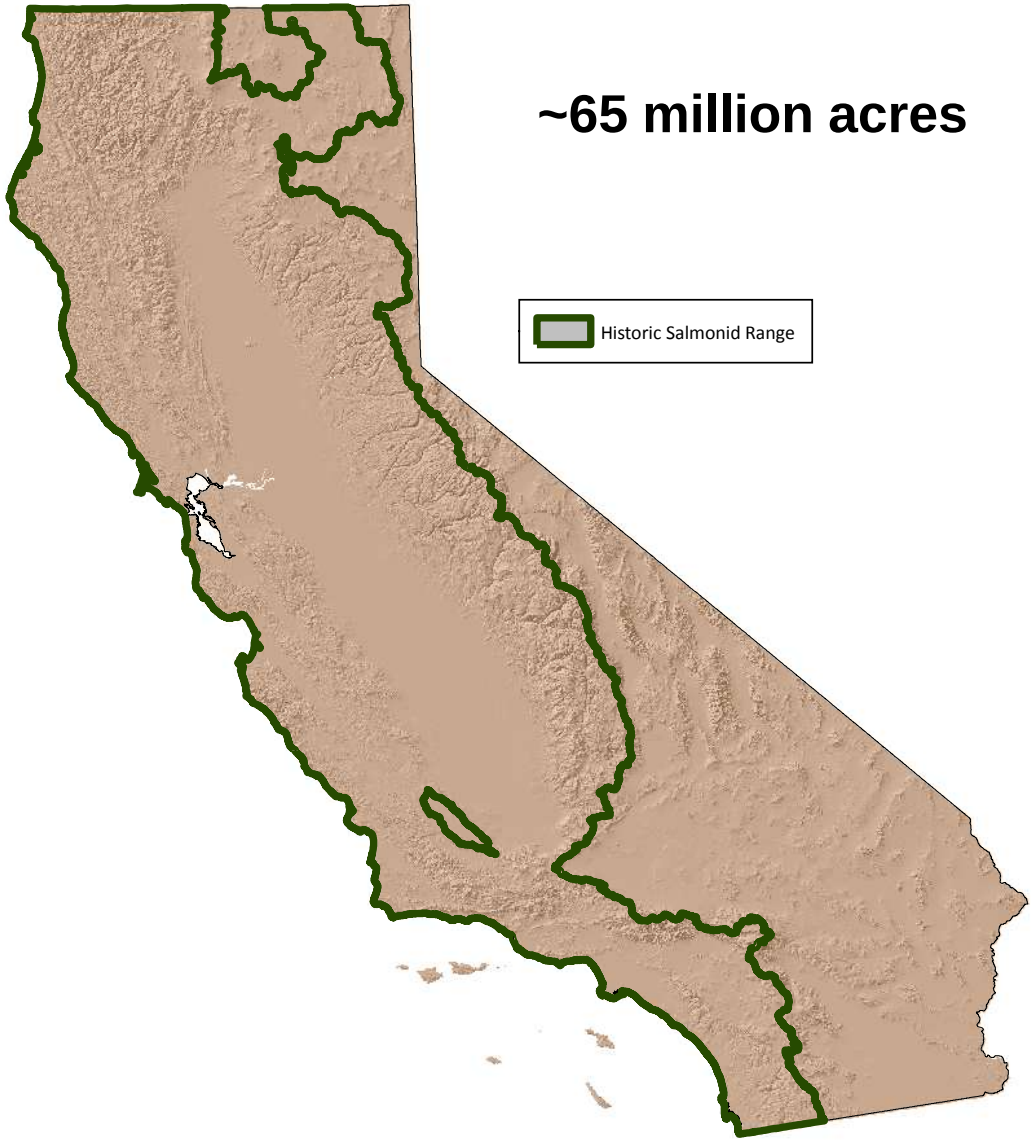
Brian Cluer, Ph.D.
Fluvial Geomorphologist

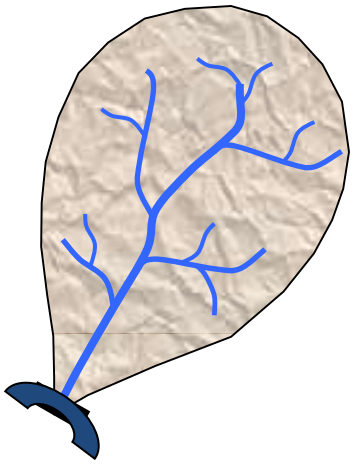
California and the World Ocean 2010

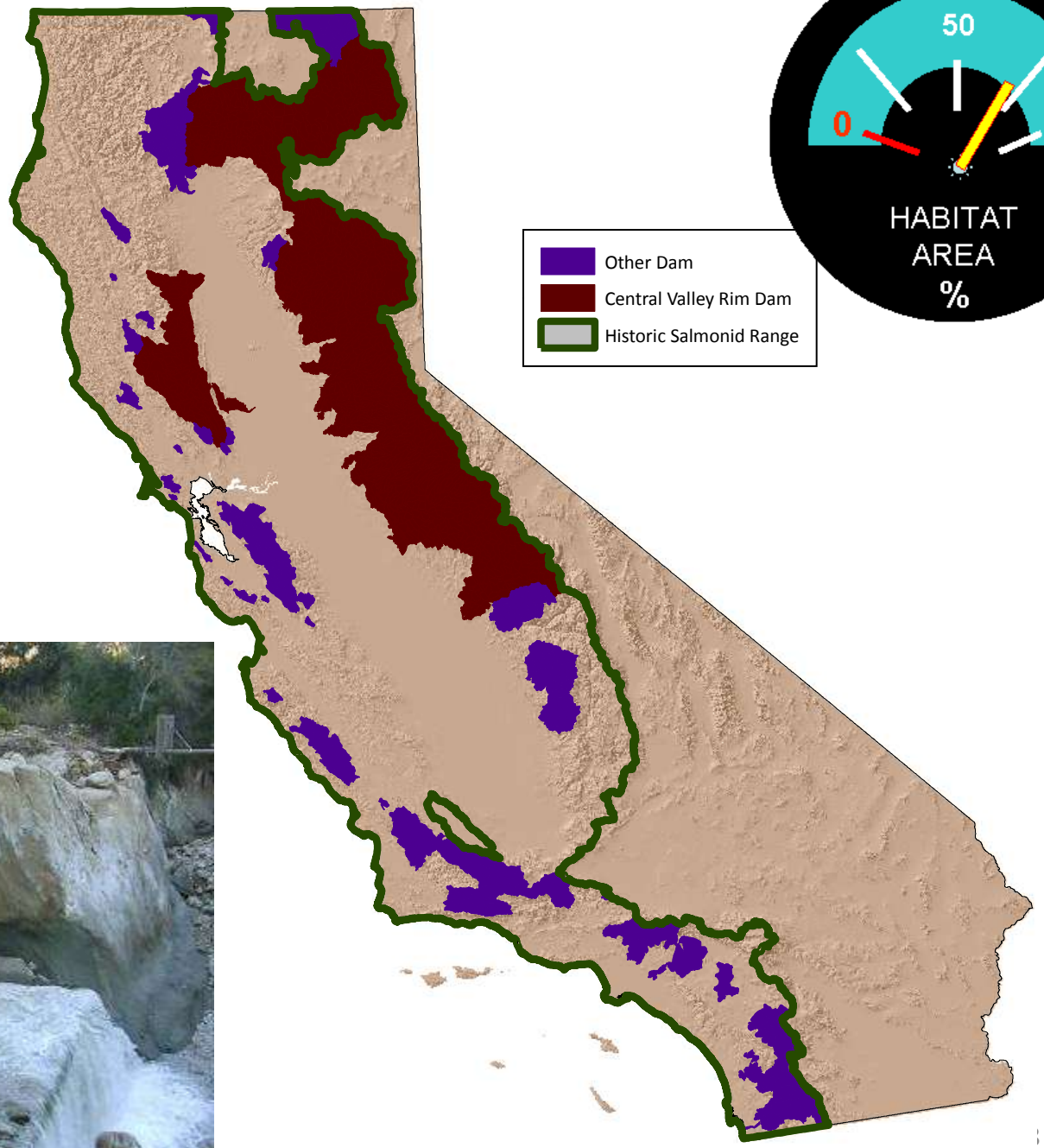


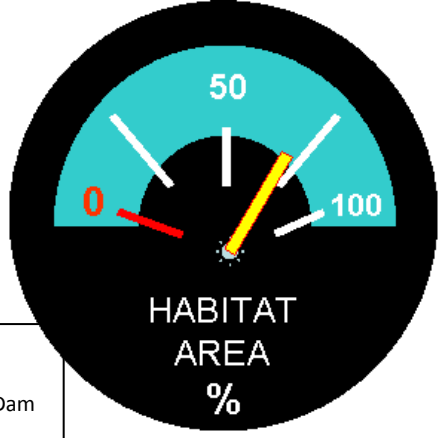
Historic Habitat

~65 million acres

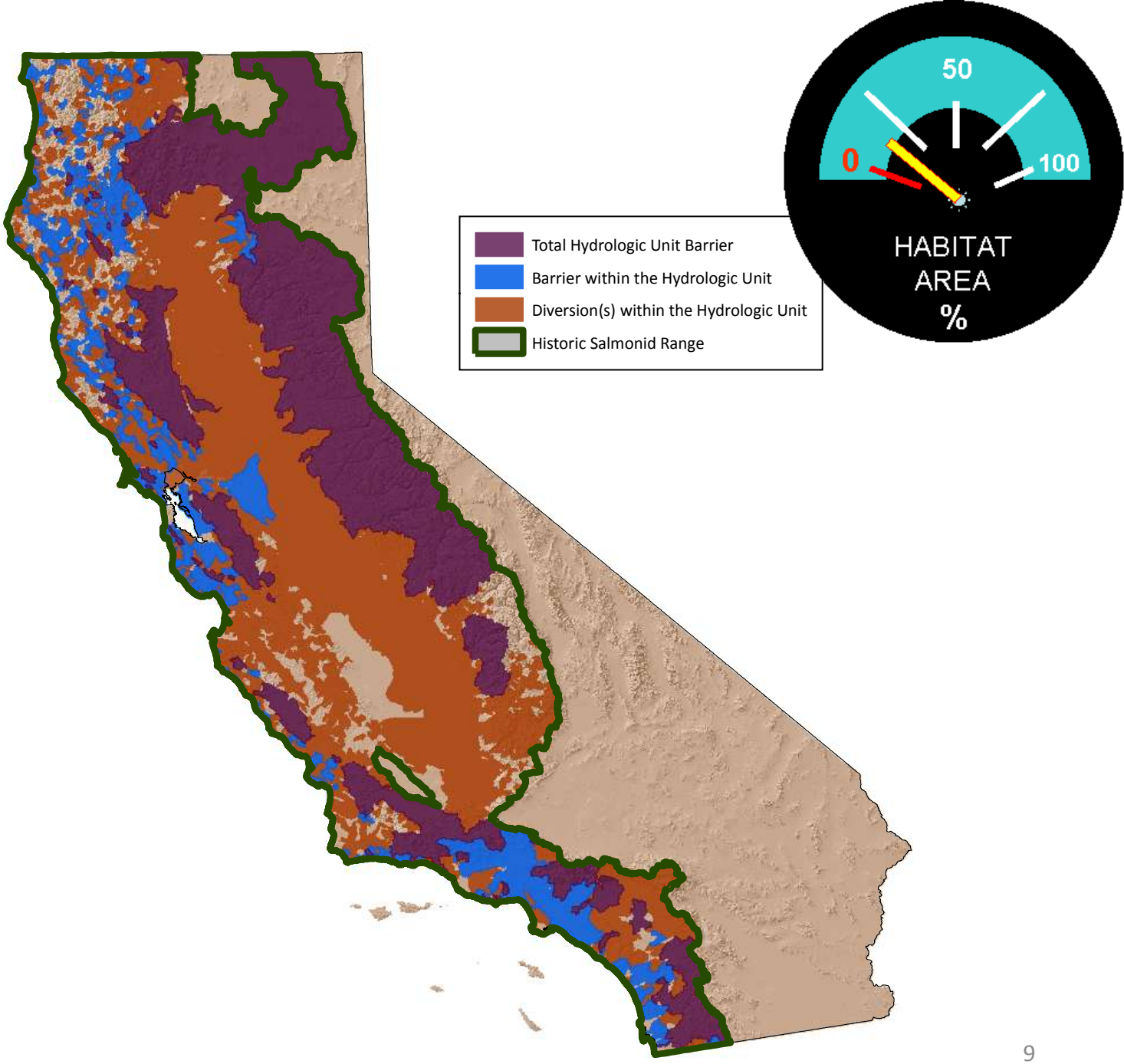




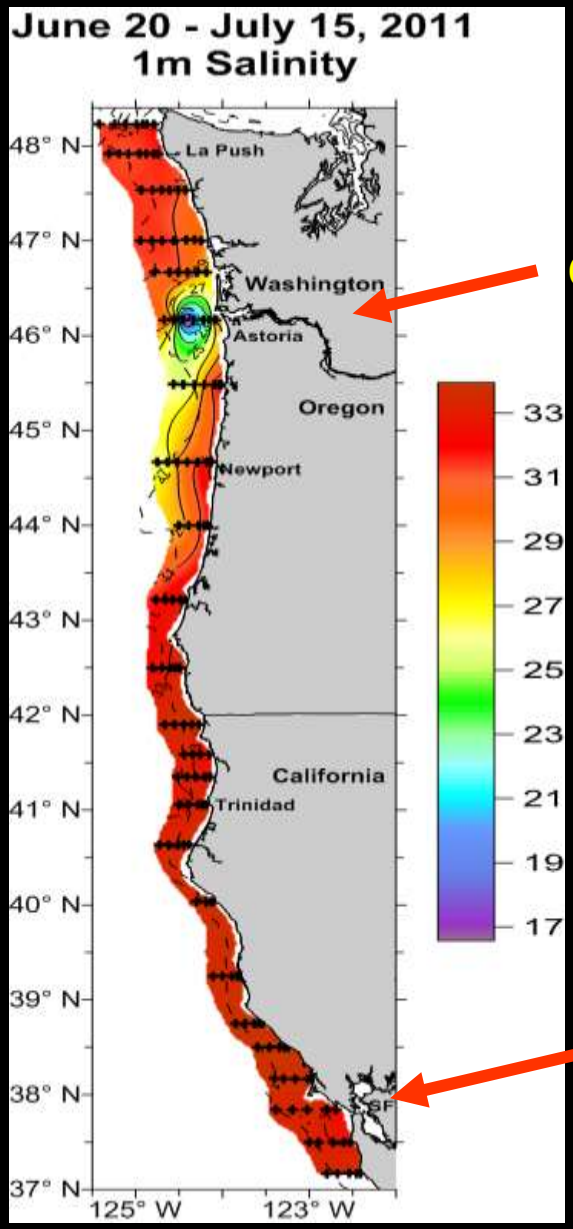

Other Dam
Central Valley Rim Dam
Historic Salmonid Range


50
0
100
HABITAT
AREA
%

Habitat Minimized:



Water- how much we got?

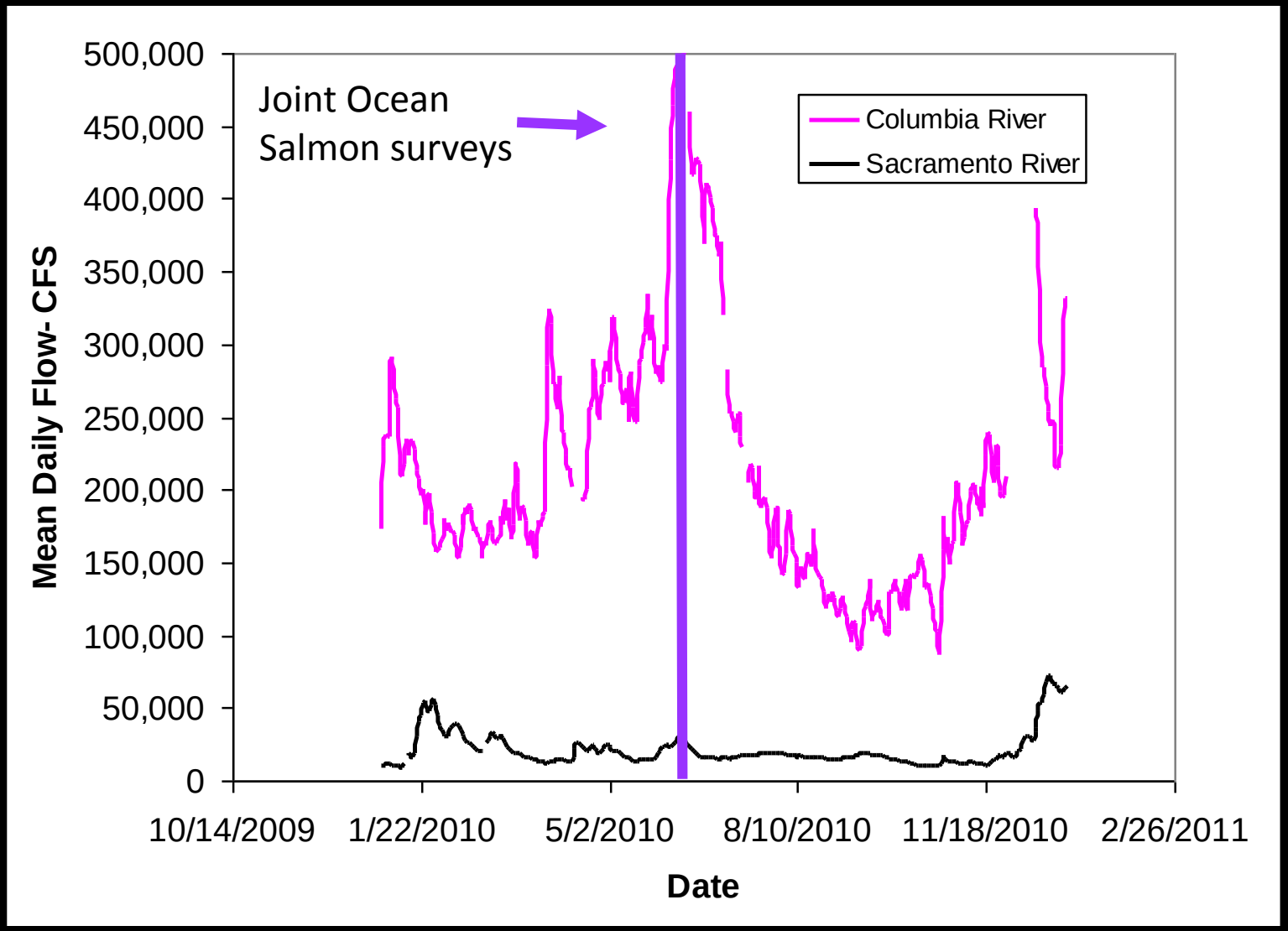


Columbia River

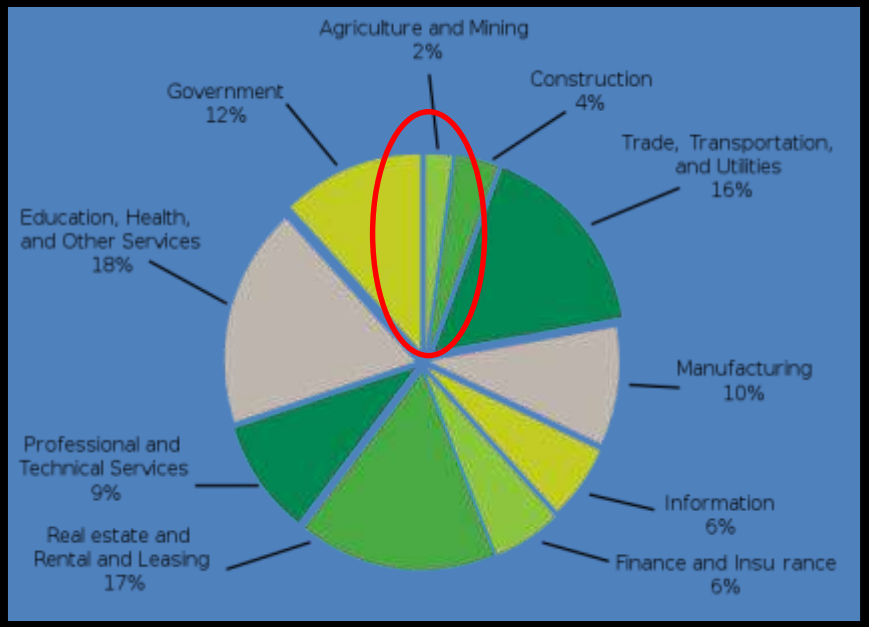
Sacramento River

Surface Salinity
(2011… a VERY wet year)

River flow comparisons



Problems in California



- Apathy (towards fish)
- 37 million people
- Introduced fisheries
- Mediterranean climate
- Industry prioritizes water diversion
- Ag industry worth $40+ Billion
  - (uses >80% of the water)

CALIFORNIA Agricultural Statistics 2012 Crop Year

Crop and Livestock Commodities in which California Leads the Nation 1/

Almonds
Apricots
Artichokes
Asparagus
Avocados
Beans, Dry Lima
Beans, F.M. Snap
Bedding/Garden Plants
Broccoli
Brussels Sprouts
Cabbage, Chinese
Cabbage, F.M.
Carrots
Cauliflower
Celery
Chicory
Cotton, American Pima
Daikon
Dates
Eggplant
Escarole/Endive
Figs
Flowers, Bulbs
Flowers, Cut
Flowers, Potted Plants
Garlic
Grapes, Raisins
Grapes, Table
Grapes, Wine
Greens, Mustard
Hay, Alfalfa
Herbs
Kale
Kiwifruit
Kumquats
Lemons
Lettuce, Head
Lettuce, Leaf
Lettuce, Romaine
Limes
Mandarins & Mandarin Hybrids 2/
Melons, Cantaloupe
Melons, Honeydew
Milk
Milk Goats
Nectarines
Nursery, Bedding Plants
Nursery Crops
Olives
Onions, Dry
Onions, Green
Parsley
Peaches, Clingstone
Peaches, Freestone
Pears, Bartlett
Peppers, Chile
Peppers, Bell
Persimmons
Pigeons and Squabs
Pistachios
Plums
Plums, Dried
Pluots
Pomegranates
Raspberries
Rice, Sweet
Safflower
Seed, Alfalfa
Seed, Bermuda Grass
Seed, Ladino Clover
Seed, Vegetable and Flowe
Spinach
Strawberries
Tomatoes, F.M.
Tomatoes, Processing
Vegetables, Greenhouse
Vegetables, Oriental
Walnuts
Wild Rice

1/ California is the sole producer (99 percent or more) of the commodities in **bold**.

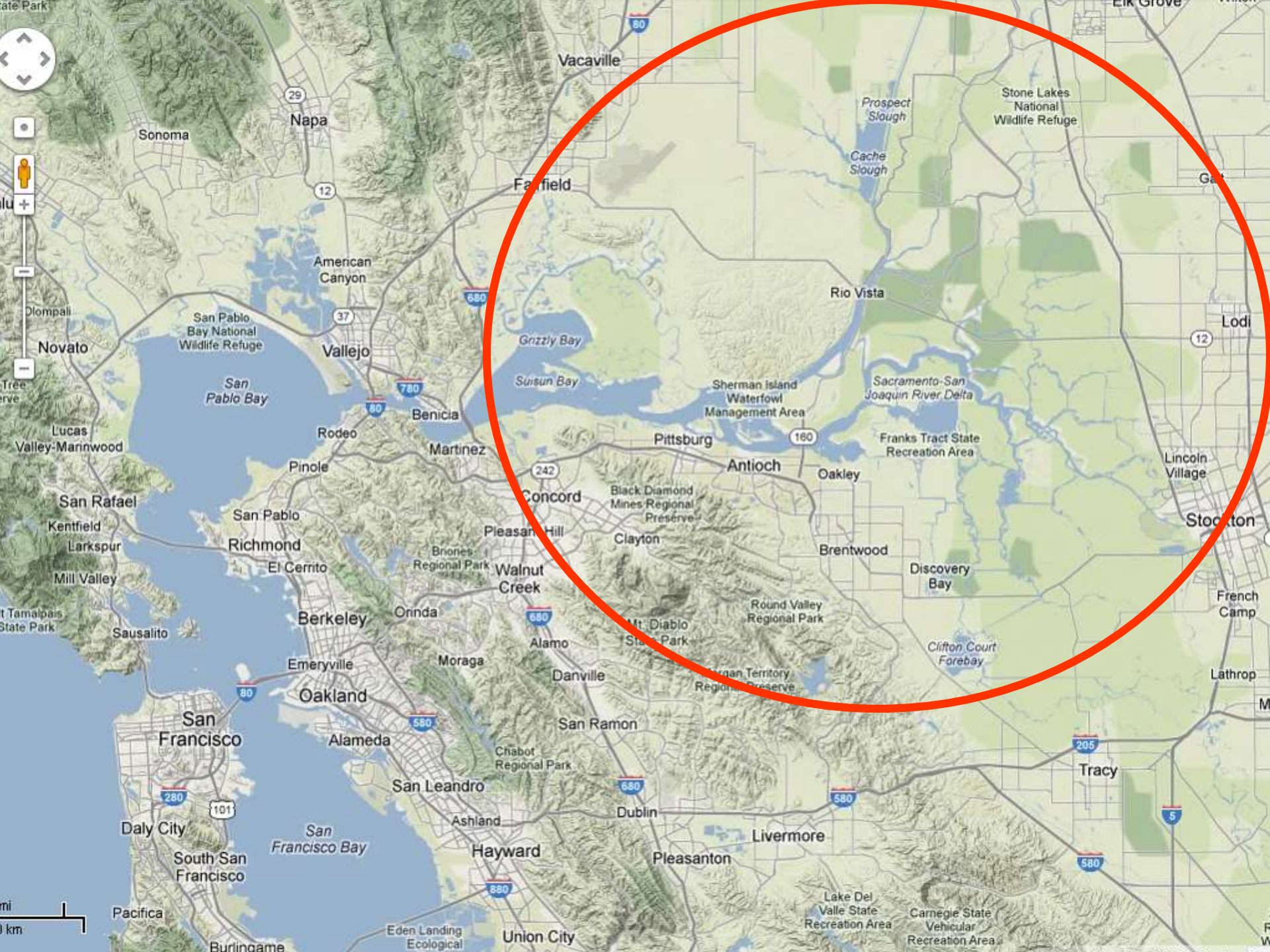
Value of Top California Ag Products

Commodity	2012	
	x $1000	
Milk and Cream	6,899,743	1
Grapes	4,450,626	2
Almonds (shelled)	4,347,200	3
Cattle & Calves	3,298,548	4
Nursery	2,551,200	5
Berries, All Strawberries	2,121,574	6
Hay, All	1,782,705	7
Lettuce, All	1,447,933	8
Walnuts	1,363,000	9*
Tomatoes	1,169,666	10
Pistachio	1,113,020	11
Flowers and Foliage	985,400	12
Rice	770,697	13

California Water Wars

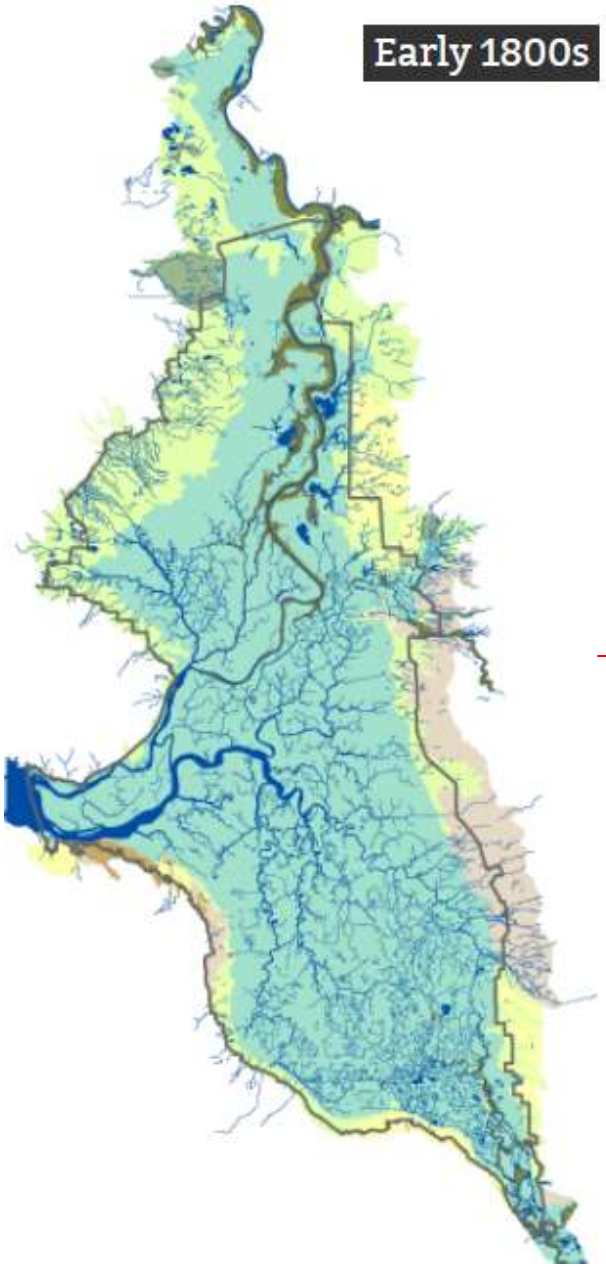
"Whiskey is for Drinking,
Water is for Fighting!"

Mark Twain



Vacaville
Napa
Sonoma
Fairfield
Prospect Slough
Cache Slough
Stone Lakes National Wildlife Refuge
Elk Grove
American Canyon
Rio Vista
Lodi
Novato
San Pablo Bay National Wildlife Refuge
Vallejo
Grizzly Bay
Suisun Bay
San Pablo Bay
Sherman Island Waterfowl Management Area
Sacramento-San Joaquin River Delta
Benicia
Rodeo
Martinez
Pittsburg
Franks Tract State Recreation Area
Lucas Valley-Marinwood
Pinole
Antioch
Oakley
Lincoln Village
San Rafael
Concord
Black Diamond Mines Regional Preserve
Kentfield
San Pablo
Pleasant Hill
Clayton
Stockton
Larkspur
Richmond
Briones Regional Park
Brentwood
El Cerrito
Walnut Creek
Discovery Bay
Mill Valley
Round Valley Regional Park
French Camp
Berkeley
Orinda
Mt. Diablo State Park
Sausalito
Alamo
Clifton Court Forebay
Emeryville
Moraga
Danville
Lathrop
Oakland
San Francisco
San Ramon
Alameda
Chabot Regional Park
Tracy
San Leandro
Dublin
Daly City
Ashland
Livermore
San Francisco Bay
Hayward
Pleasanton
South San Francisco
Lake Del Valle State Recreation Area
Carnegie State Vehicular Recreation Area
Pacifica
Eden Landing Ecological
Union City
Burlingame

http://science.kqed.org/quest/delta-map/



Compare the Delta Across Eras

Click on the habitat types below to see how the Delta's waterways and landscape have been changed.

- Show All
- Agriculture
- Urban
- Water
- Freshwater Wetland
- Willow Thicket
- Riparian Forest
- Seasonal Wetland
- Dune Scrub
- Grassland
- Oak Woodland

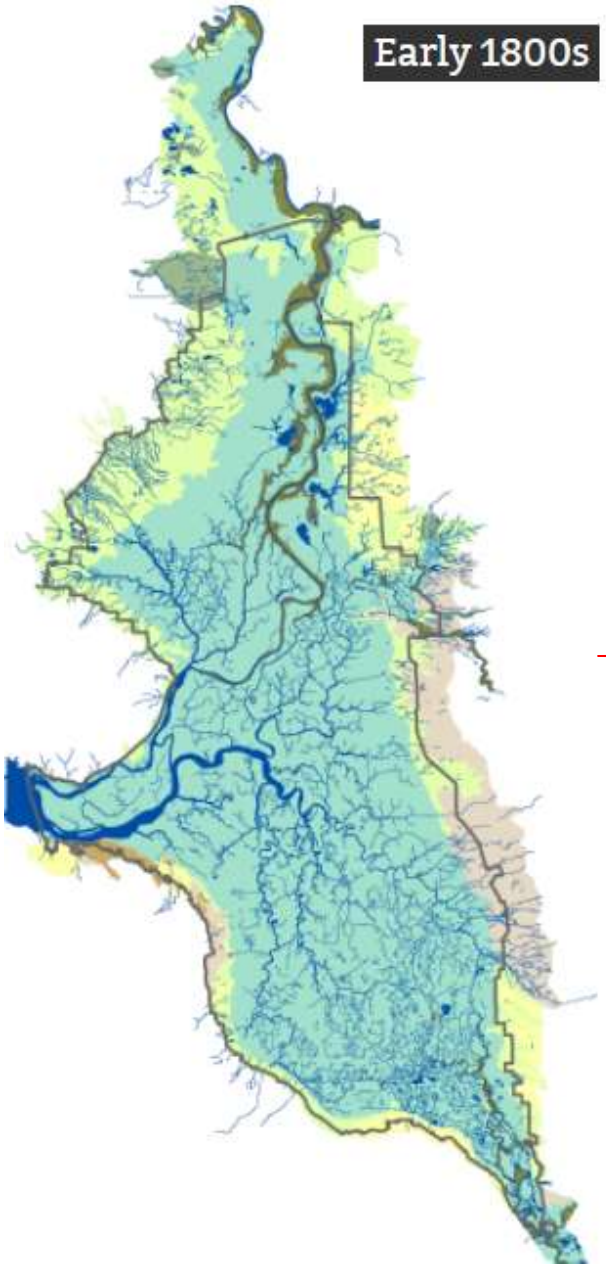
Note:
The outline on the map at left indicates the mutually mapped area. The outline on the map at right indicates the boundary of the SFEI-ASC study.

Magnitude of Reclamation in the Sacramento-San Joaquin Delta, CA, 1860–1930

Decade	Hectares Reclaimed	Cumulative Hectares
1860-1870	6,070	6,070
1870-1880	37,231	43,301
1880-1890	28,328	71,629
1890-1900	23,472	95,101
1900-1910	35,612	130,713
1910-1920	38,040	168,753
1920-1930	9,712	178,465

Source: Thompson 1957

http://science.kqed.org/quest/delta-map/



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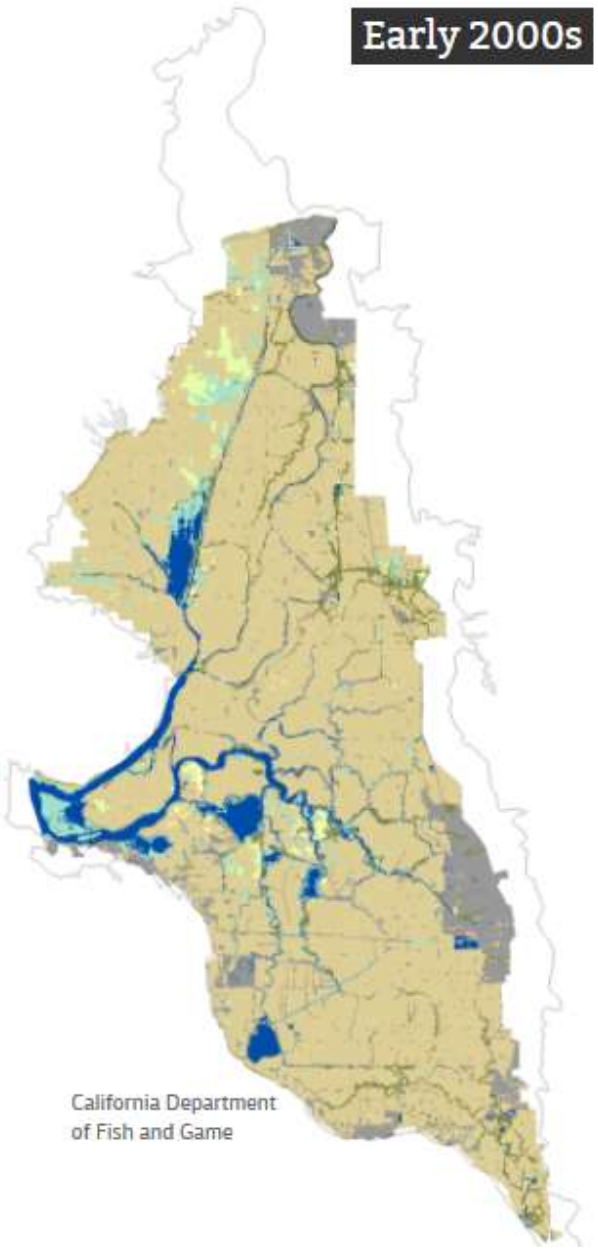
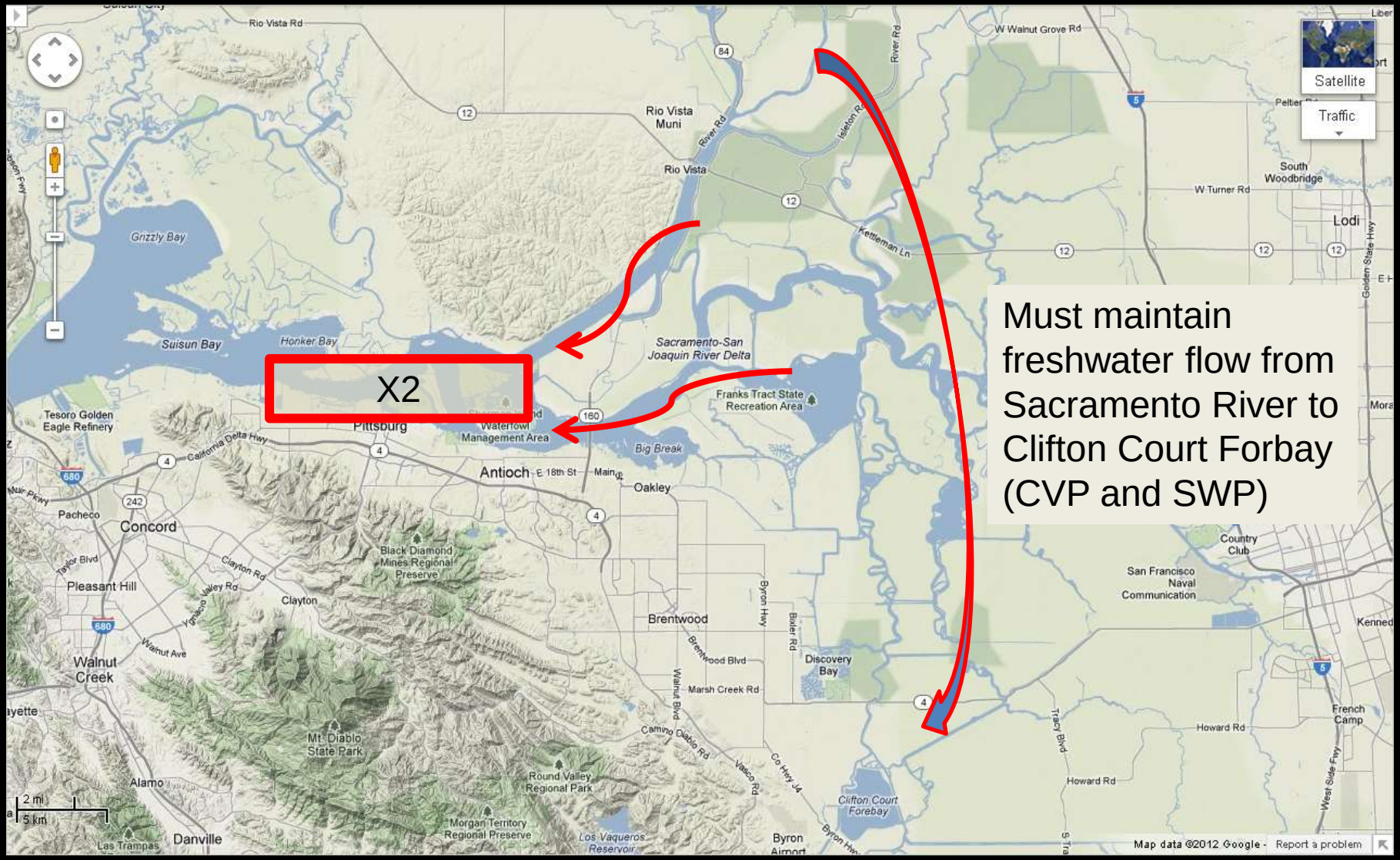
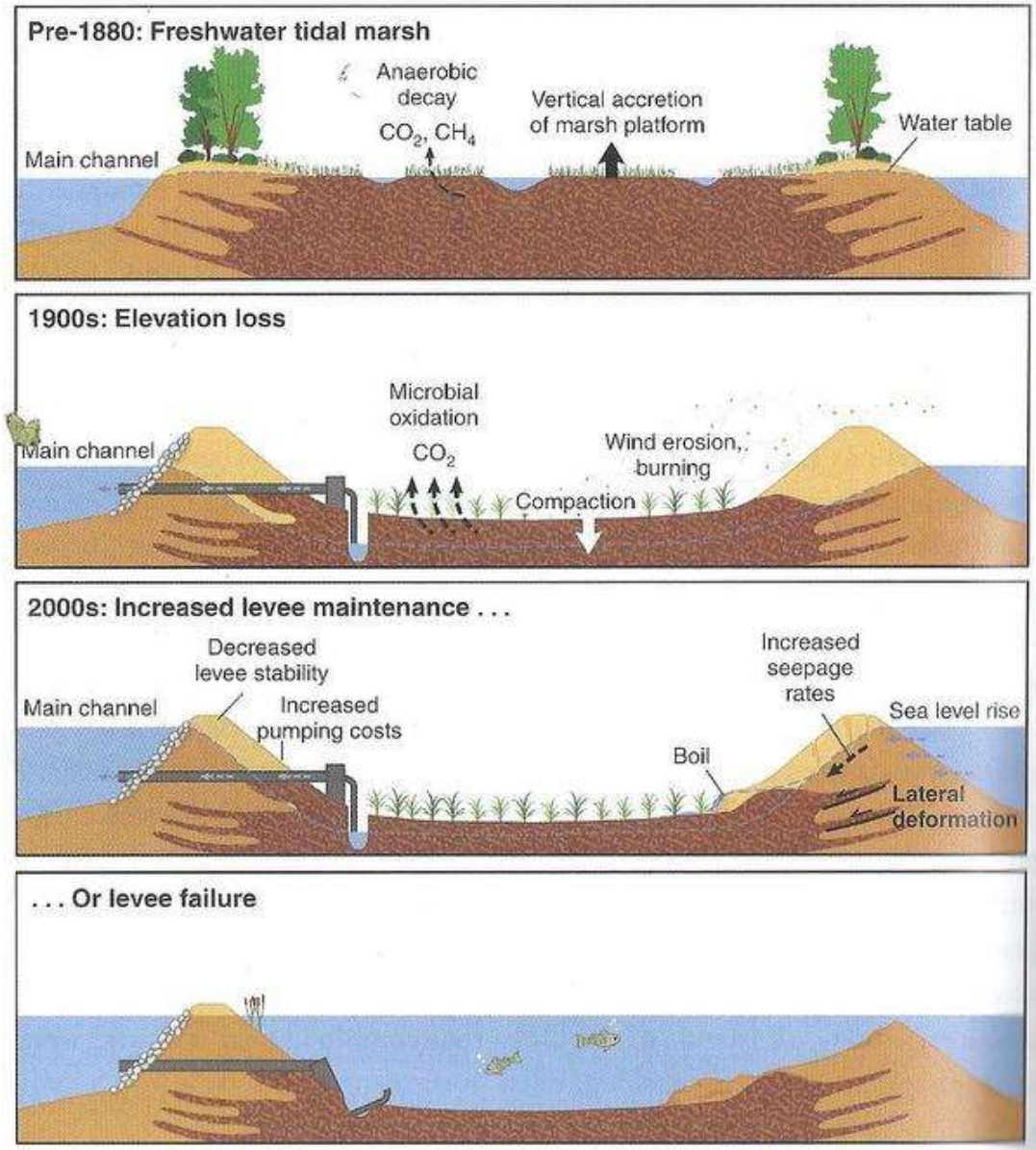



X2
Must maintain freshwater flow from Sacramento River to Clifton Court Forbay (CVP and SWP)
Rio Vista Rd
Rio Vista Muni
Rio Vista
River Rd
W Walnut Grove Rd
Satellite
Traffic
South Woodbridge
W Turner Rd
Lodi
Kettleman Ln
Grizzly Bay
Suisun Bay
Honker Bay
Sacramento-San Joaquin River Delta
Franks Tract State Recreation Area
Tesoro Golden Eagle Refinery
Pittsburg
Waterfowl Management Area
Big Break
California Delta Hwy
Antioch
E 18th St
Main St
Oakley
Pacheco
Concord
Pleasant Hill
Taylor Blvd
Clayton Rd
Clayton
Black Diamond Mines Regional Preserve
Brentwood
Byron Hwy
Bixler Rd
Brentwood Blvd
Marsh Creek Rd
Discovery Bay
Walnut Creek
Walnut Ave
Mt. Diablo State Park
Camino Diablo Rd
Vasco Rd
Co Hwy J4
Round Valley Regional Park
Morgan Territory Regional Preserve
Los Vaqueros Reservoir
Clifton Court Forebay
Byron Airport
Alamo
Danville
Las Trampas
Tracy Blvd
Howard Rd
San Francisco Naval Communication
Country Club
French Camp
West Side Fwy
Golden State Hwy
2 mi
5 km
Map data ©2012 Google - Report a problem

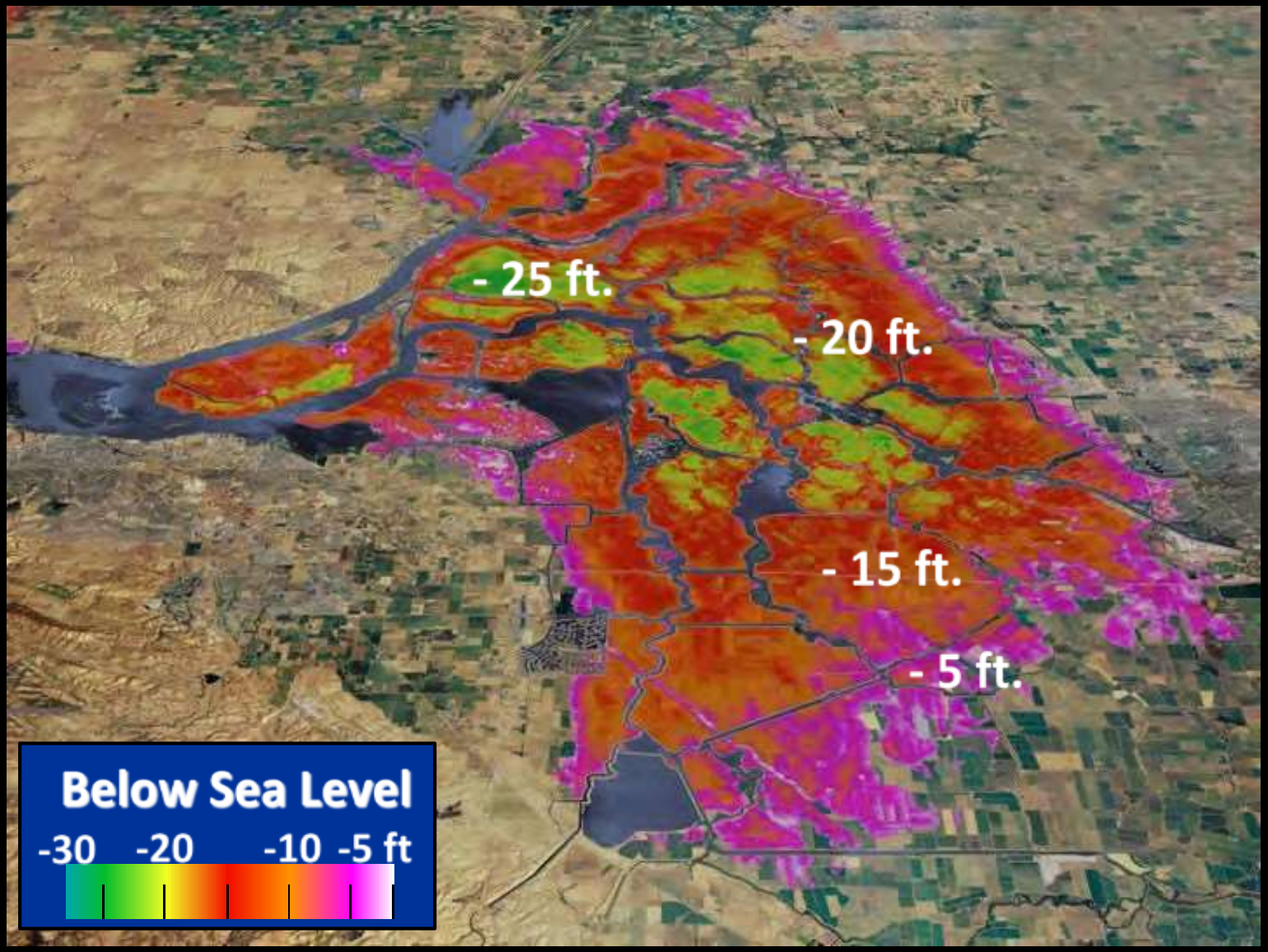


SOURCE: Mount and Twiss (2005). Reproduced under the terms of the Creative Commons Attribution License.

Figure 3.1—Conceptual Diagram Illustrating the Historical and Future Trajectory of Island Subsidence in the Delta

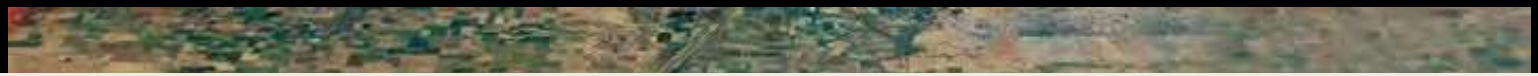
Lund et al. 2007 Envisioning futures for the Sacramento-San Joaquin Delta

SUBSIDENCE



DWR

SUBSIDENCE



The Delta

- 1100 km of River Channel
- 1800 km of levees
- earth and stone 3-15m+ high
- 2000 km^2 land below 3-9m <sea level

Sensitivity to Storms and Earthquakes?

2005 Hurricane Katrina

2004 Indian Ocean earthquake (9.2- Sumatra-Andaman Quake)

2012 Hurricane Sandy

2011 Tōhoku earthquake and tsunami

2013 Typhoon Haiyan

The ultimate Gordian knot

- 2002 USACE predicts 99% chance of flooding within 50 years on 13 Delta islands
- 2006 Ca DWR projects 1ft rise in sea level will increase the frequency of a 100-year peak tide to a 10-year event.
- There have been >160 levee failures in the Delta over the past century (Jeff Mount says 'they are better now'… improved last 20 years)
- Such massive levee failures could result in the loss to California's economy of $30-40 billion
- Impact freshwater supply for 25 million of people

http://newscenter.berkeley.edu/2010/04/20/delta

The ultimate Gordian knot

- 2002 USACE predicts 99% chance of floodin ithin 50 years on 13 Delta islands
- 2006 Ca DWR projects 1ft rise in sea se the frequency of a 100-year peak tide
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- Such massive levee fail the loss to California's econom
- Impact freshwa ion of people

RISK....?

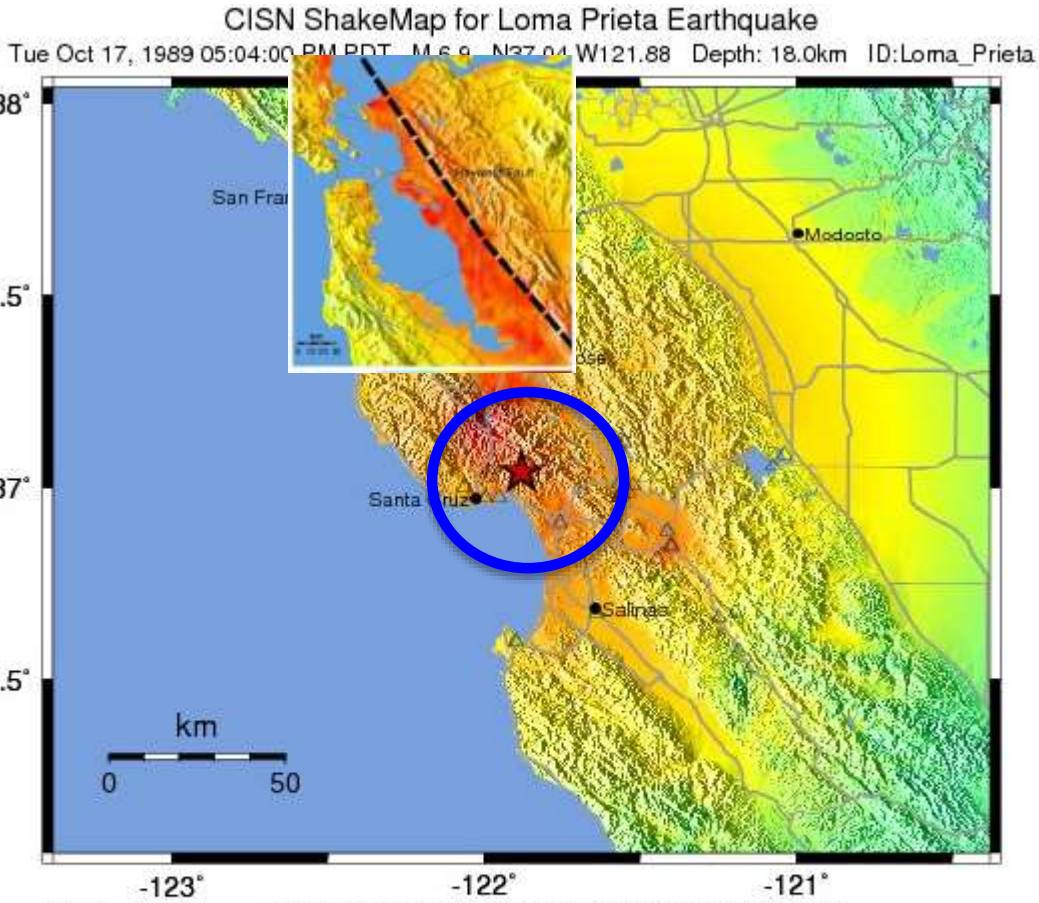
http://newscenter.berkeley.edu/2010/04/20/delta

From the BDCP …..

Delta Risk Management Strategy Phase 1 study evaluated the performance of Delta levees under various seismic threat scenarios, and analyzed potential consequences to a variety of factors including for water supply, water quality, ecosystem values, and public health and safety.

The study concluded that a major earthquake of magnitude 6.7 or greater in the vicinity of the Delta Region has a **62 percent** probability of occurring sometime between 2003 and 2032 (DWR 2009a).

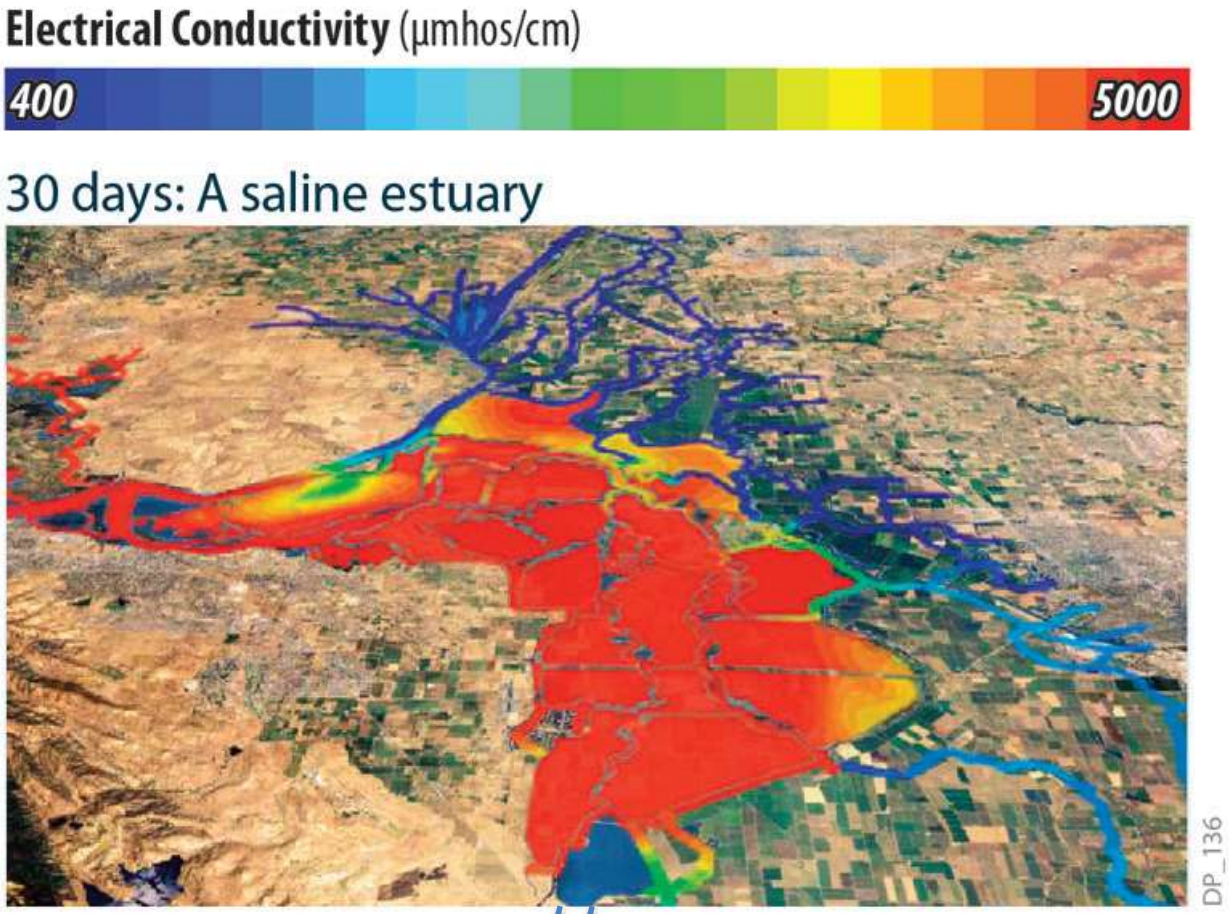
Loma Prieta 6.9 Earthquake 1989



Map Version 3 Processed Fri Oct 13, 2006 10:12:35 AM PDT, -- NOT REVIEWED BY HUMAN

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124

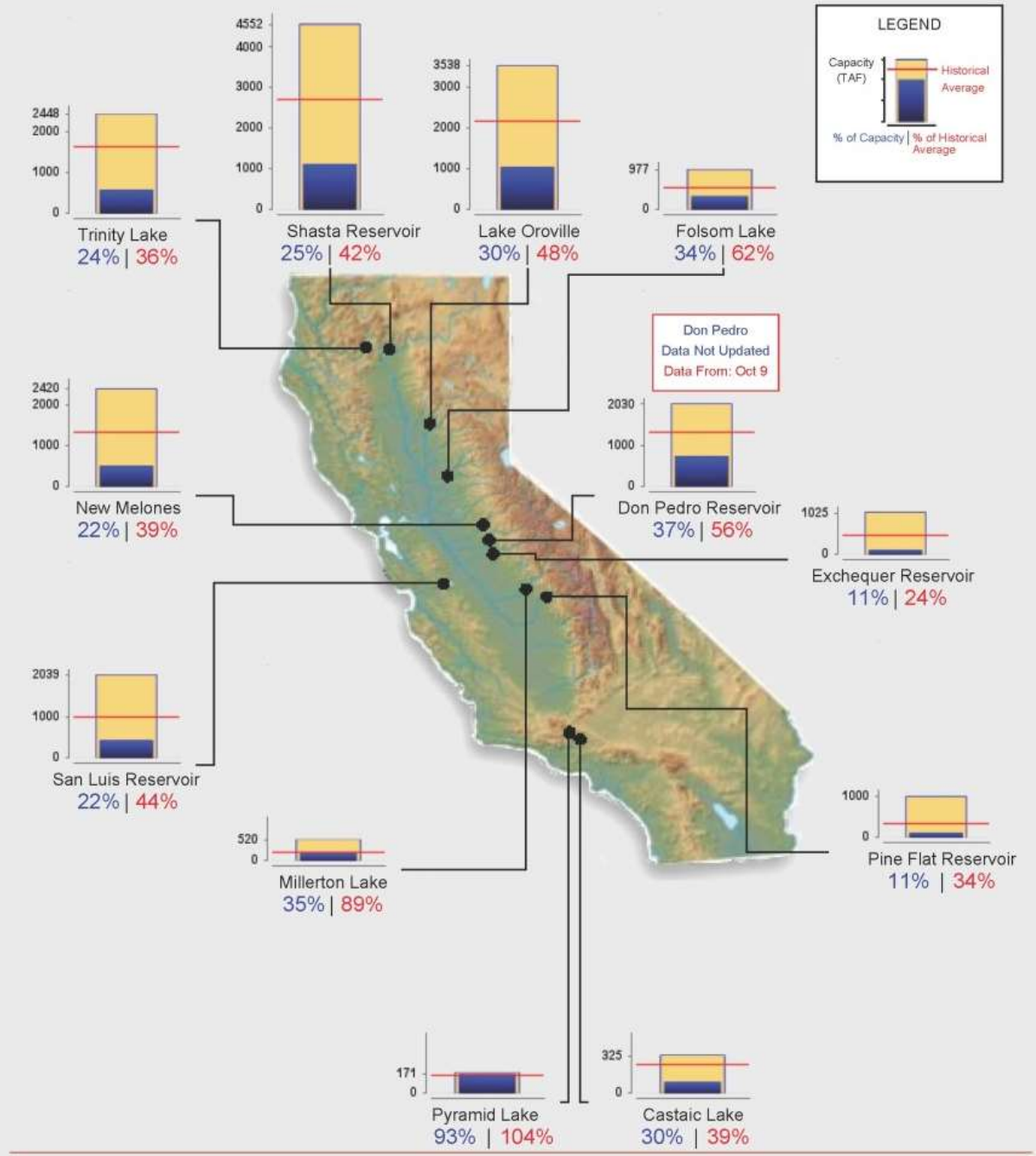
The simulation (only a 6.5)

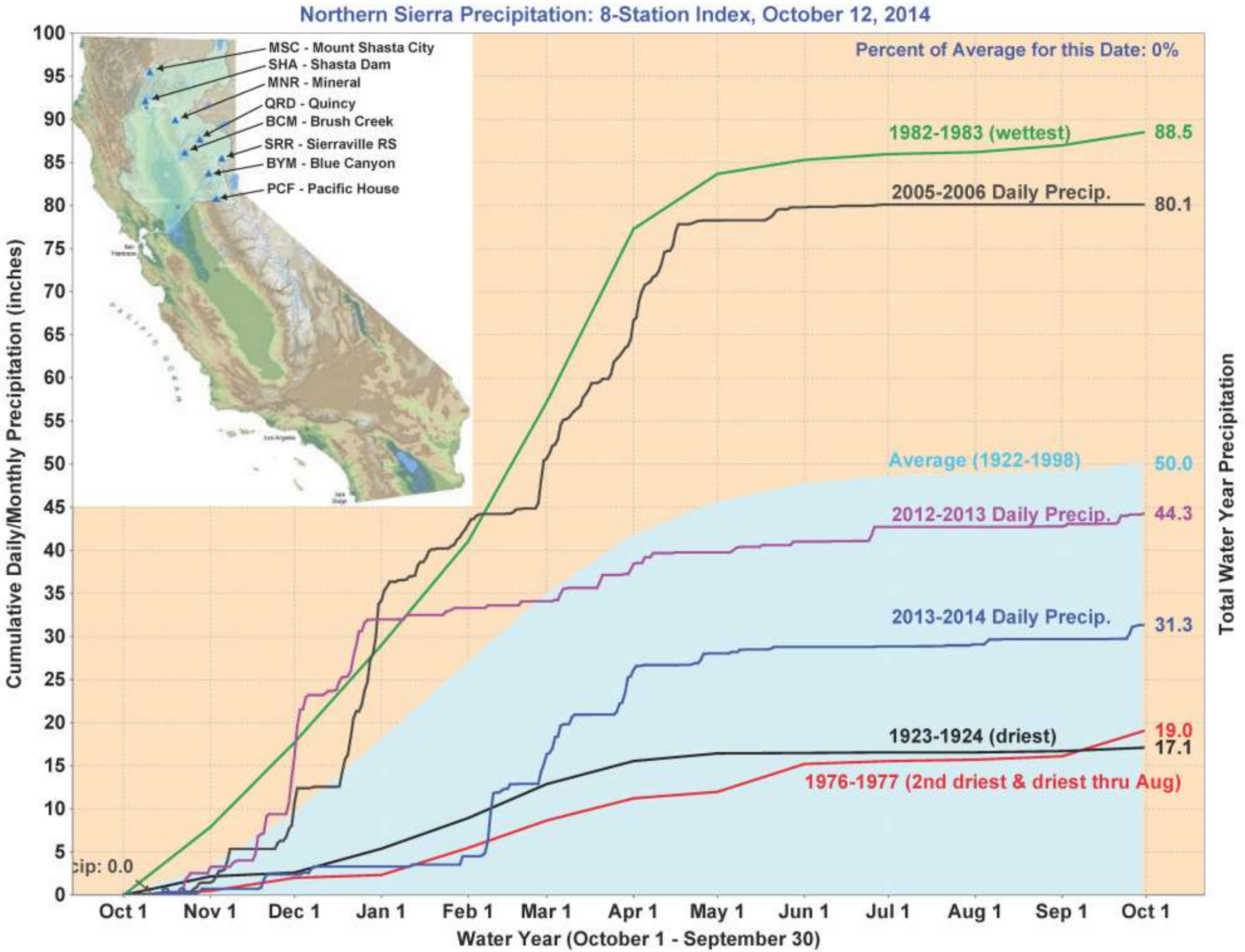


Southern California….

Ending At Midnight - October 11, 2014

CURRENT RESERVOIR CONDITIONS

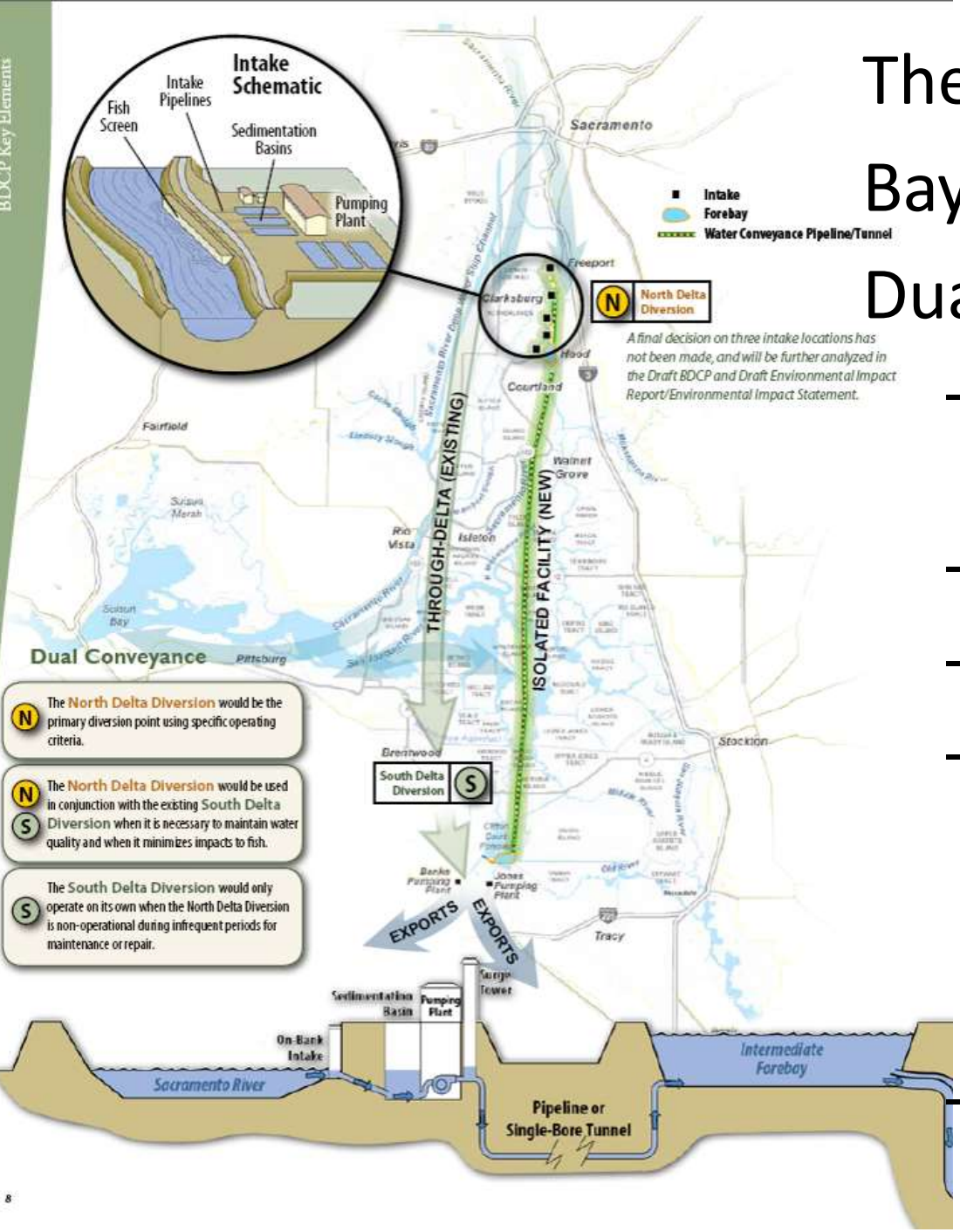



Northern Sierra Precipitation: 8-Station Index, October 12, 2014
MSC - Mount Shasta City
SHA - Shasta Dam
MNR - Mineral
QRD - Quincy
BCM - Brush Creek
SRR - Sierraville RS
BYM - Blue Canyon
PCF - Pacific House
Percent of Average for this Date: 0%
1982-1983 (wettest)
88.5
2005-2006 Daily Precip.
80.1
Average (1922-1998)
50.0
2012-2013 Daily Precip.
44.3
2013-2014 Daily Precip.
31.3
1923-1924 (driest)
19.0
17.1
1976-1977 (2nd driest & driest thru Aug)
cip: 0.0
Cumulative Daily/Monthly Precipitation (inches)
Total Water Year Precipitation
Oct 1
Nov 1
Dec 1
Jan 1
Feb 1
Mar 1
Apr 1
May 1
Jun 1
Jul 1
Aug 1
Sep 1
Oct 1
Water Year (October 1 - September 30)

HOPE & CHANGE ON DISPLA

Environmental activism takes its toll in the San Joaquin Water C

www.jeffhead

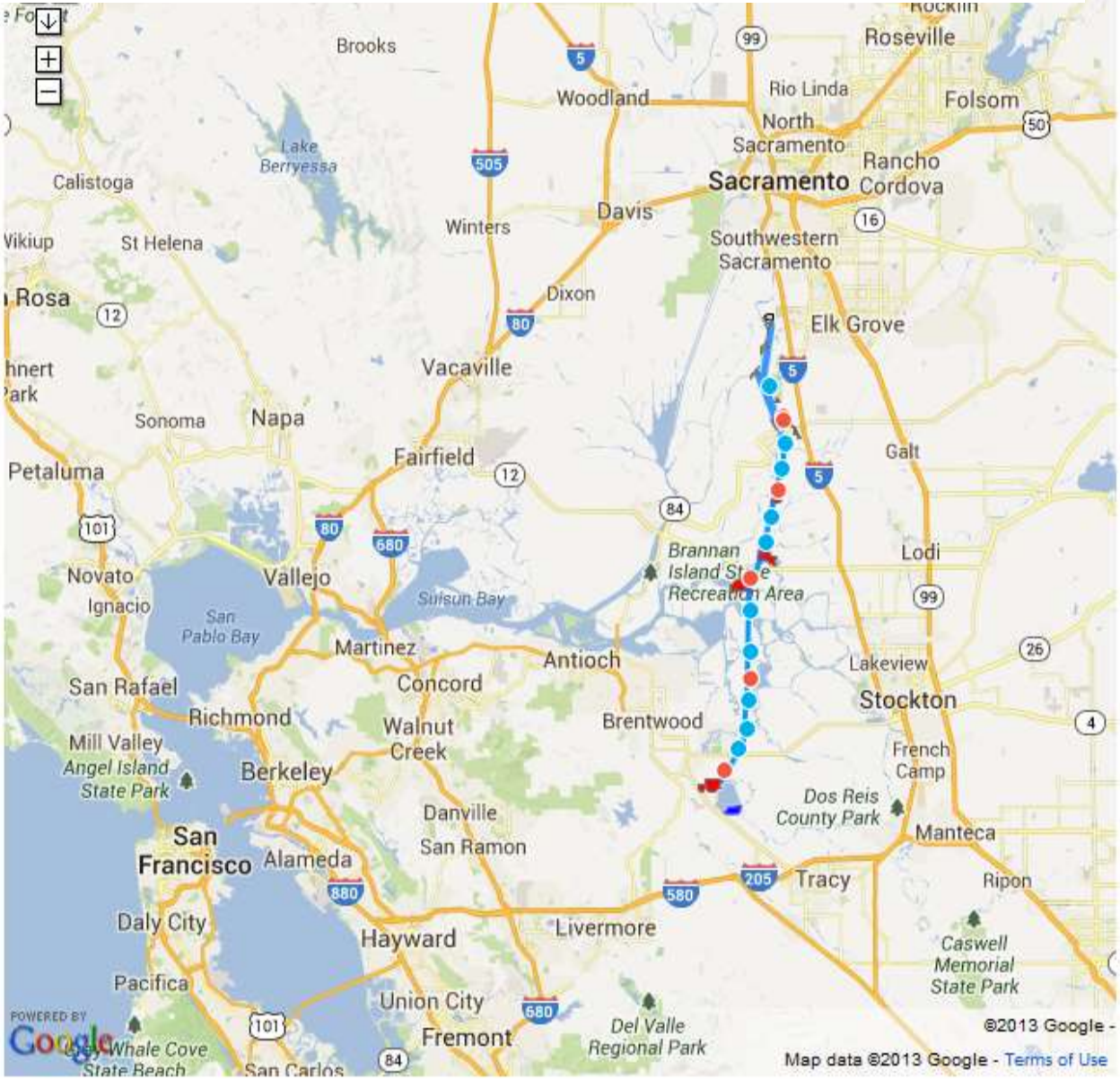


The Solution?

Bay Delta Cons. Plan - Dual Conveyance

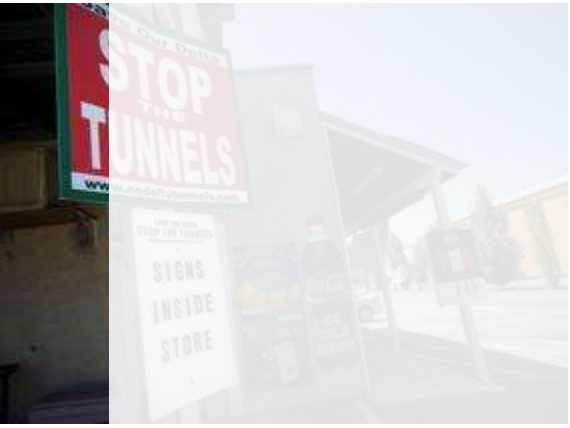
- Three 3,000 cfs capacity on-bank diversions
- Each ~1200 ft. in length
- $20 Billion+ project
- Concern to juvenile salmonids mortality from predators
- ? Ya think?

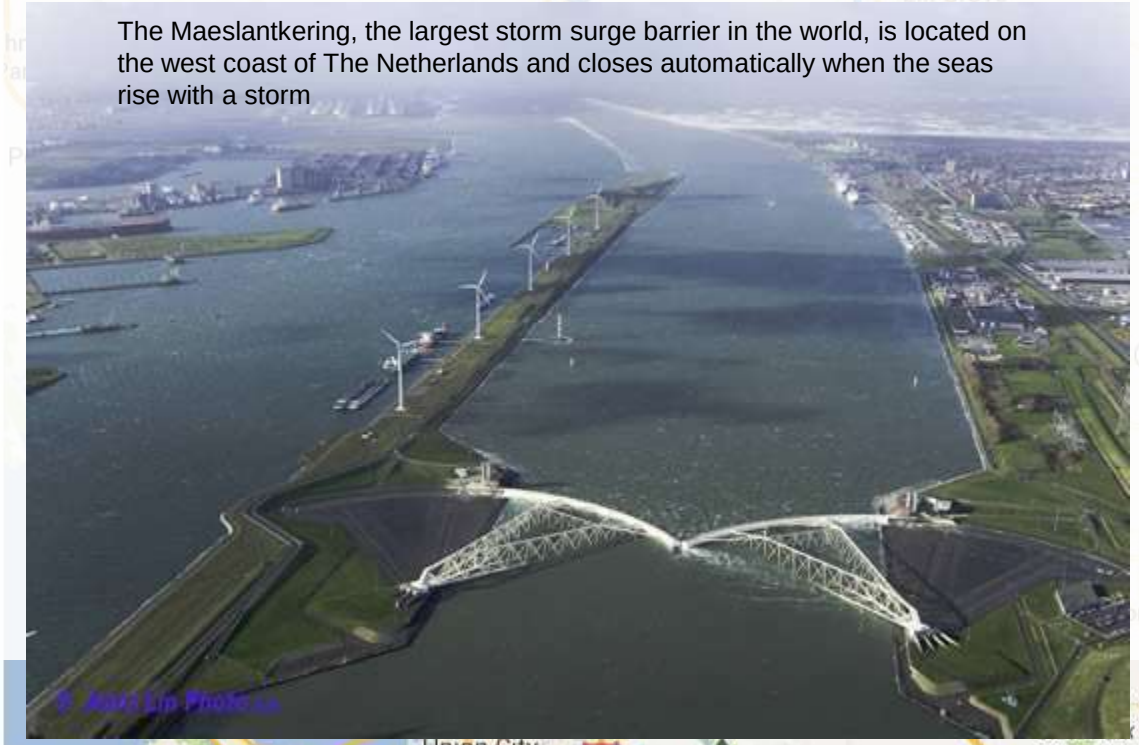
Alternatives?



Alternatives?

- Do nothing…
- Peripheral Canal (?!)
- Sea Water Barriers?

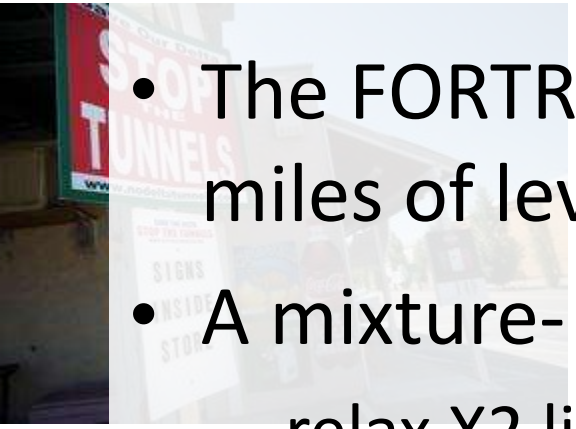


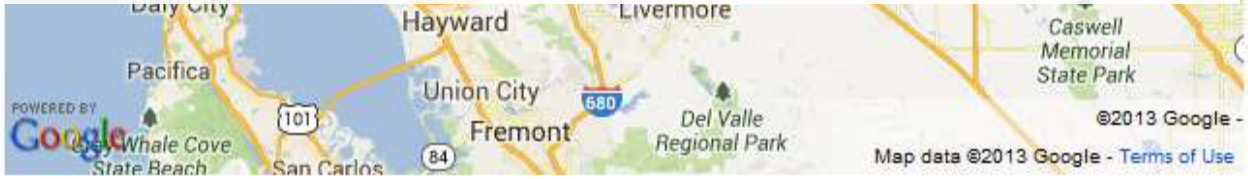


The Maeslantkering, the largest storm surge barrier in the world, is located on the west coast of The Netherlands and closes automatically when the seas rise with a storm

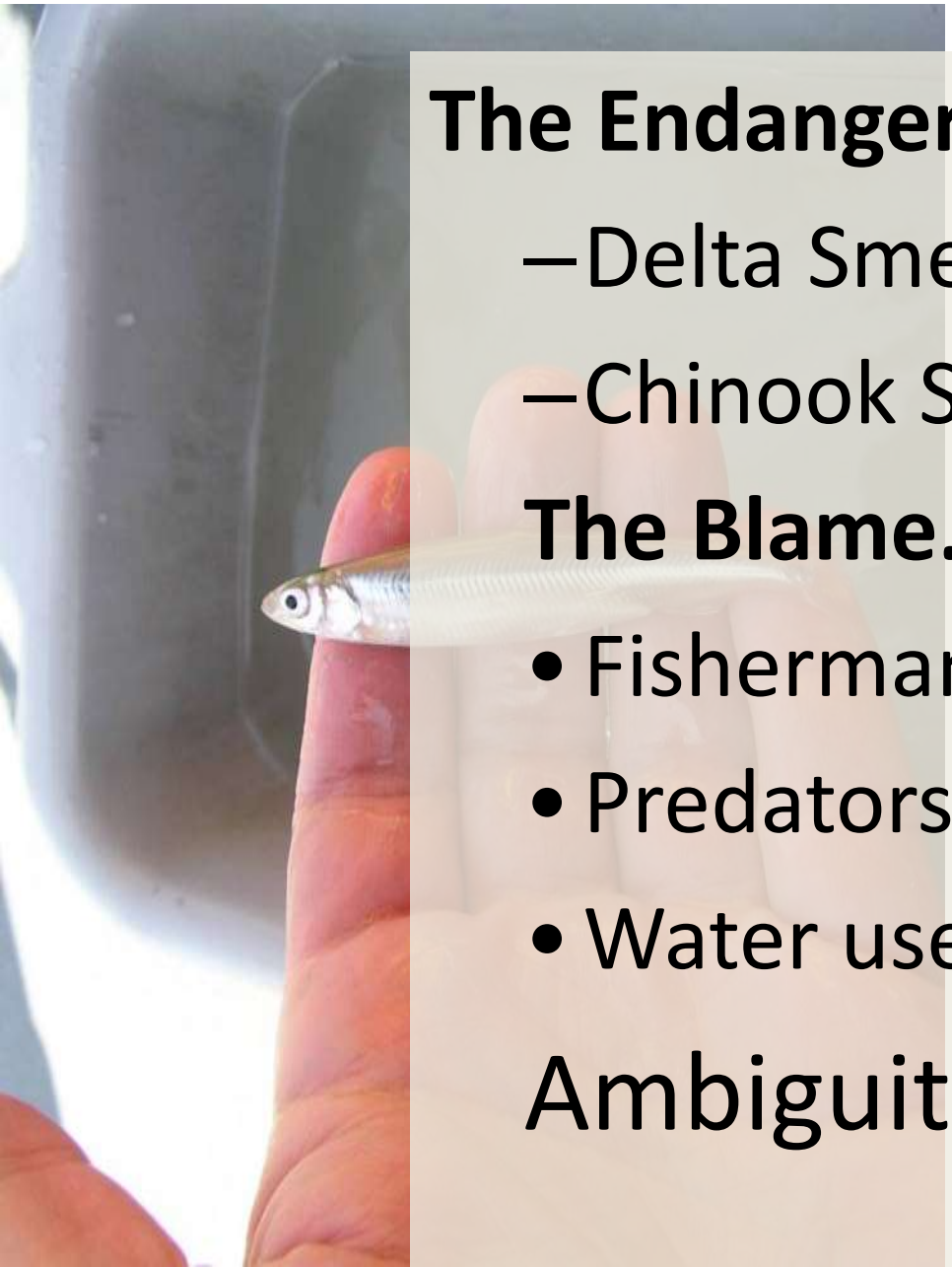
Alternatives?

- Do nothing…
- Peripheral Canal (?!)
- Sea Water Barriers?
- The FORTRESS DELTA: Armor/raise 300-600 miles of levees
- A mixture-
  - relax X2 line
  - flood a few islands
  - Relocate a communities/farms?





Why is this a NMFS problem?



The Endangered Species Act

- Delta Smelt
- Chinook Salmon

The Blame….

- Fisherman?
- Predators?
- Water use?

Ambiguity= Inaction

Risks of Inaction

- ~$250,000,000 salmon economy
- Flood safety and livelihood for 500,000 people
- $40,000,000,000 agriculture
- Fresh water supply for 25,000,000 people

Any solution requires approval by NMFS
(WCRO consultation?)

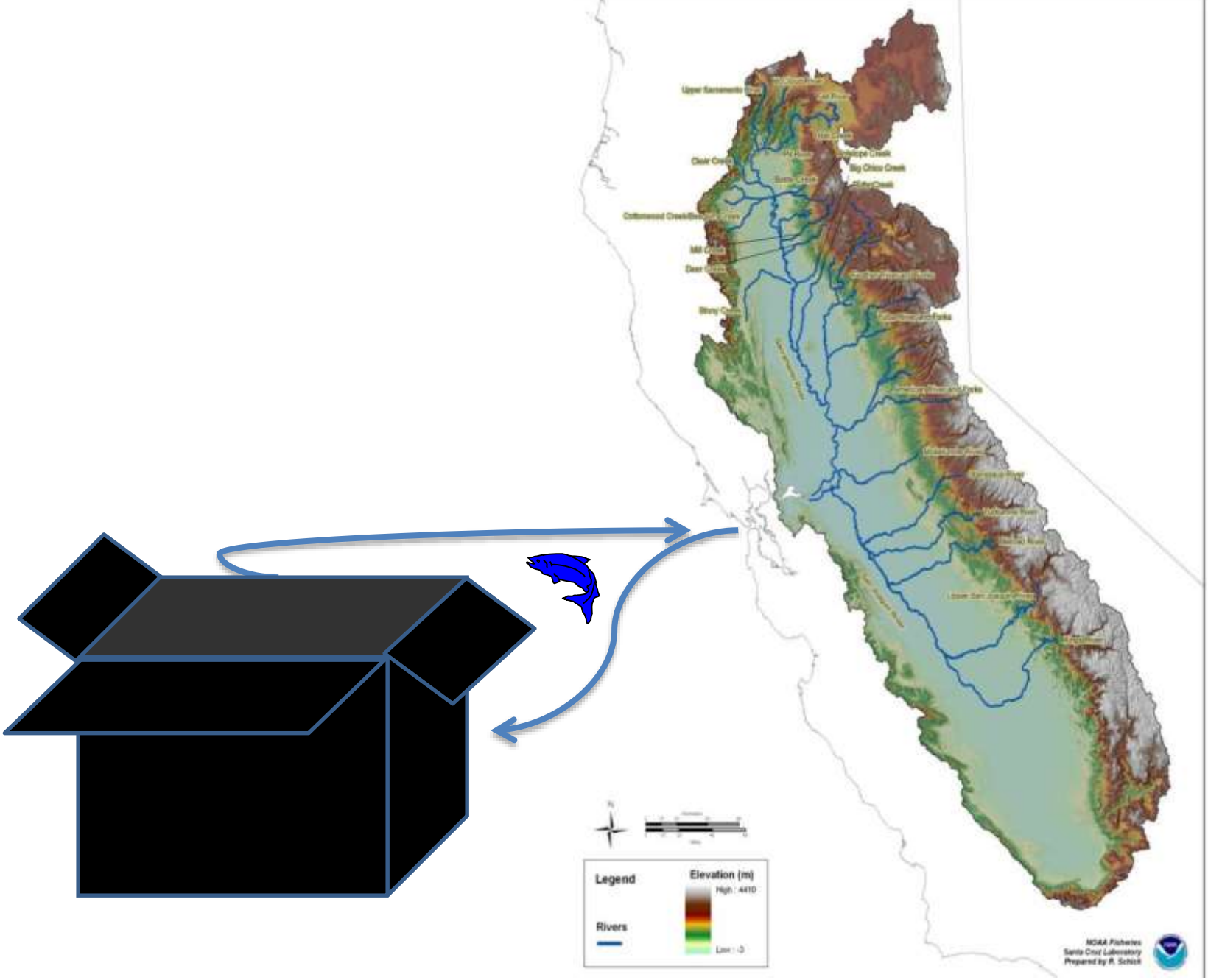
Need more data…..

Science Centers!

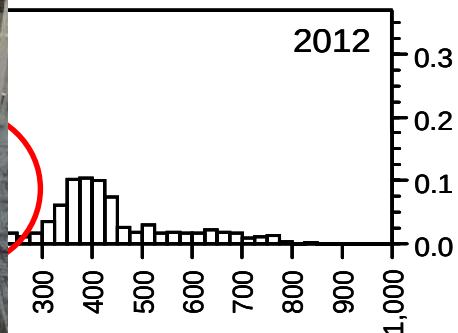
Empirical studies

- Ocean Surveys
- Juvenile outmigration survival
- Predation studies
  - Impact of water diversions
  - Removal experiments

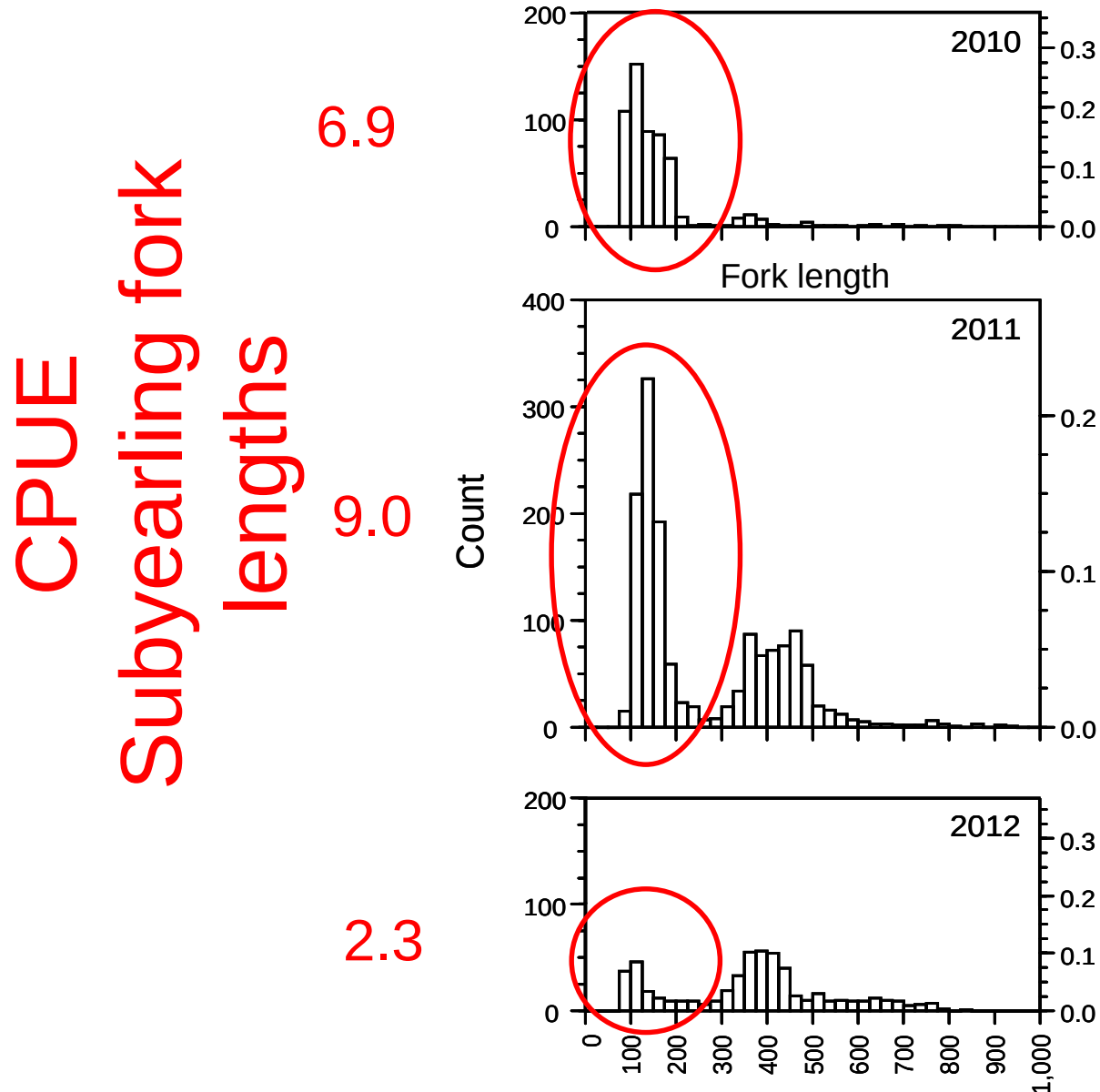
Integrated Life Cycle Modeling Efforts


Legend
Rivers
Elevation (m)
High : 4410
Low : -3
NOAA Fisheries
Santa Cruz Laboratory
Prepared by R. Schick

California Juvenile Salmon ocean trawl



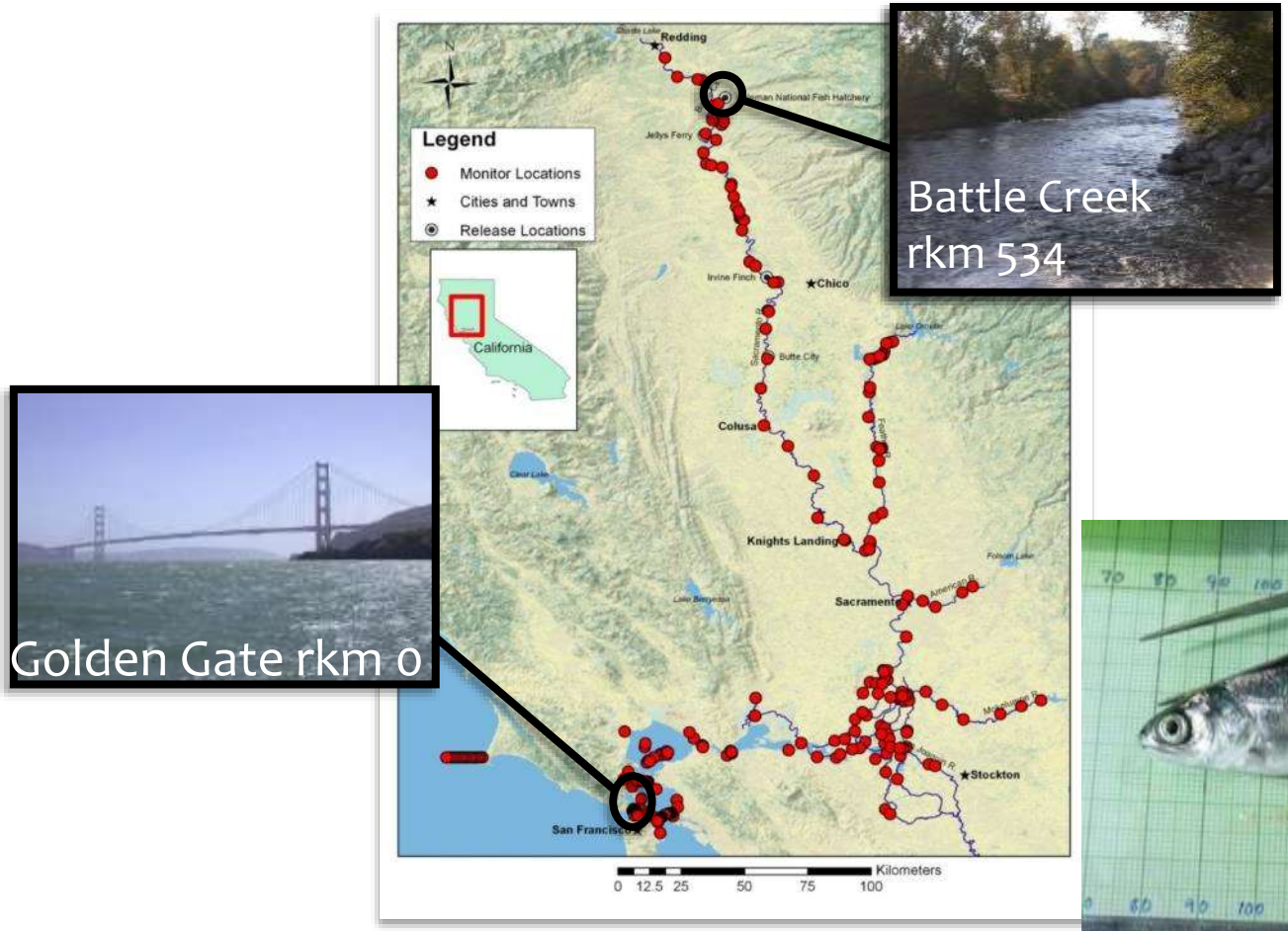
California Juvenile Salmon ocean trawl surveys suggest variable recruitment

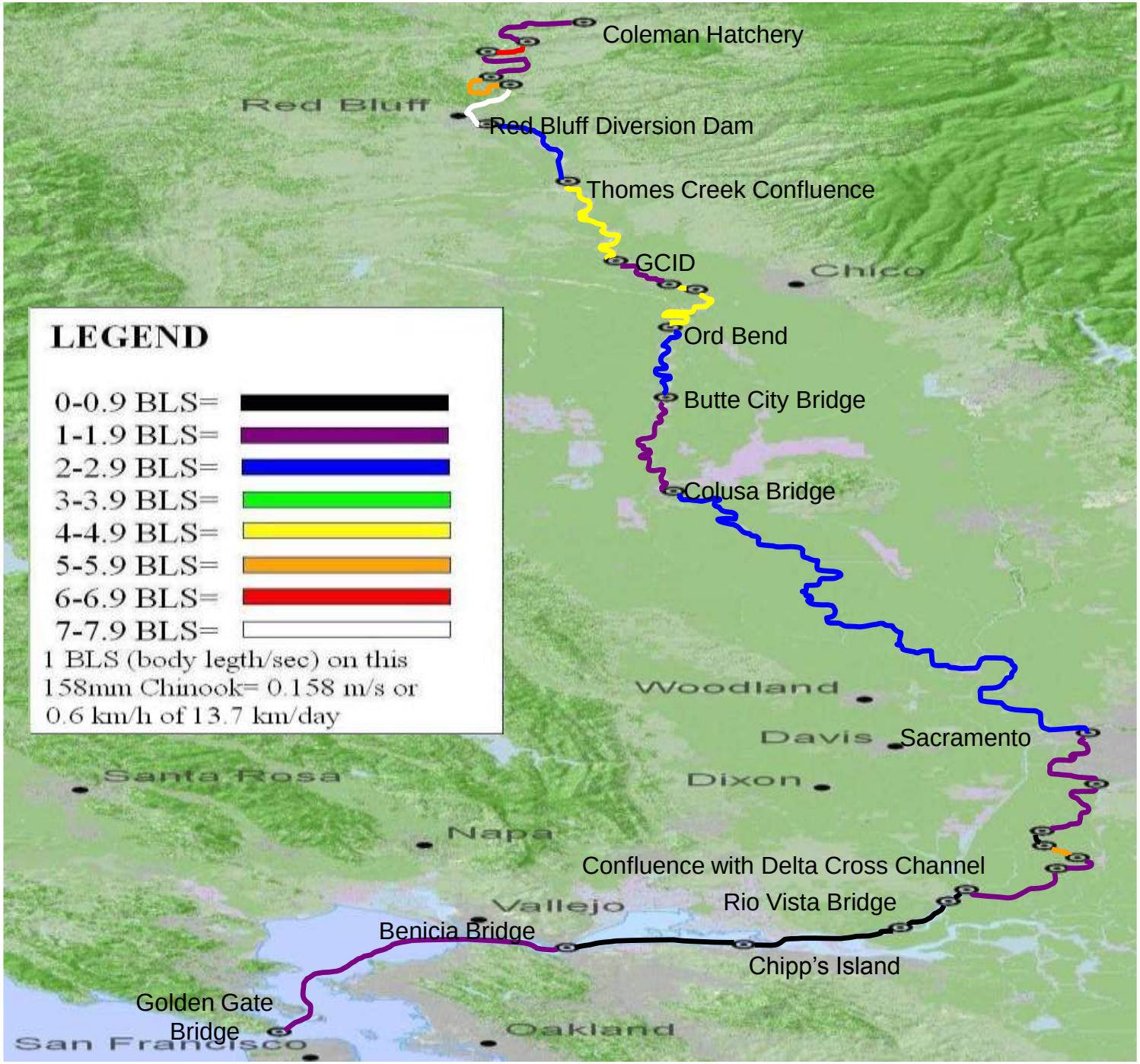


Is variability- early marine survival?

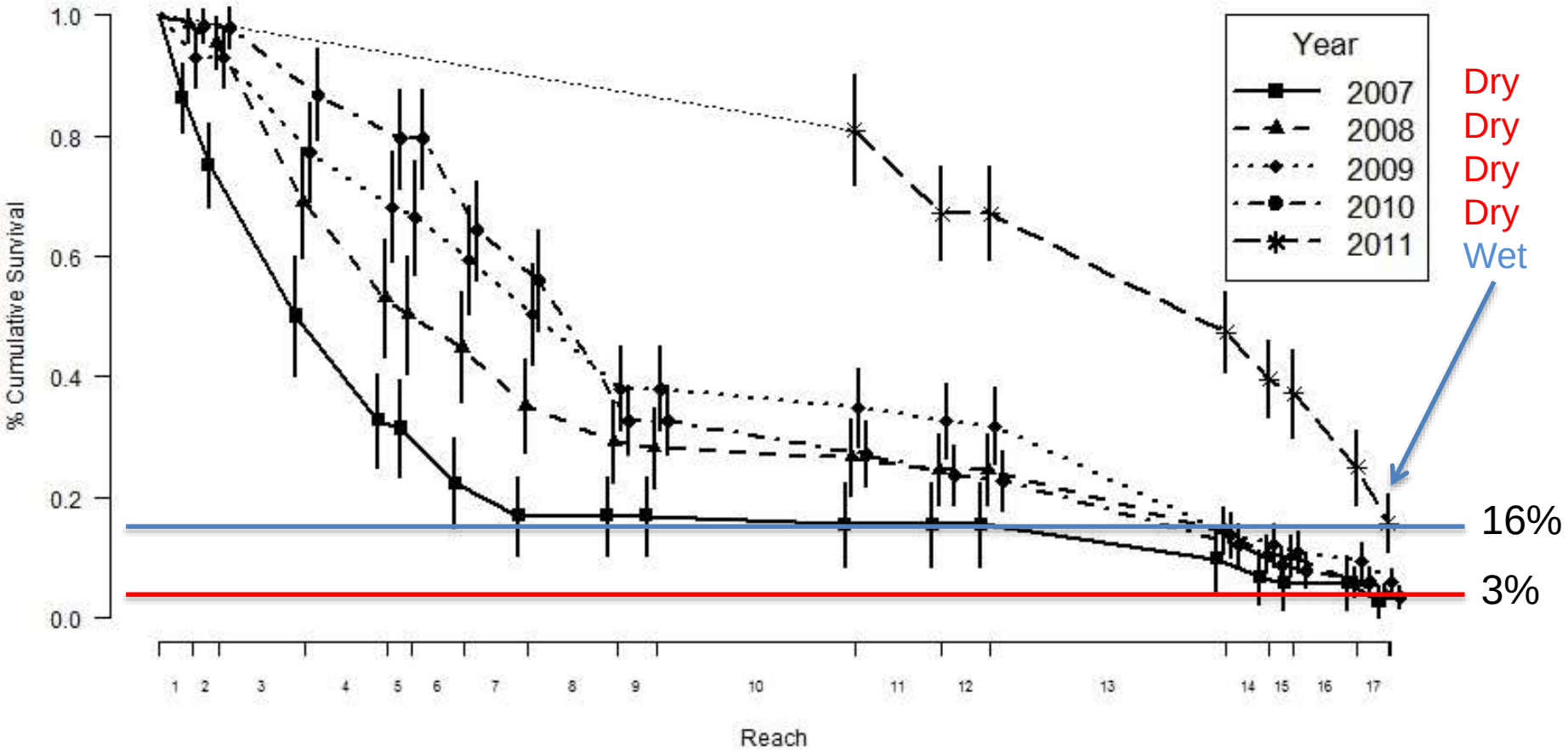
Or… river mortality?

- Measuring outmigration survival with acoustic telemetry




Coleman Hatchery
Red Bluff
Red Bluff Diversion Dam
Thomes Creek Confluence
GCID
Chico
Ord Bend
Butte City Bridge
Colusa Bridge
LEGEND
0-0.9 BLS=
1-1.9 BLS=
2-2.9 BLS=
3-3.9 BLS=
4-4.9 BLS=
5-5.9 BLS=
6-6.9 BLS=
7-7.9 BLS=
1 BLS (body legth/sec) on this
158mm Chinook= 0.158 m/s or
0.6 km/h of 13.7 km/day
Woodland
Davis
Sacramento
Santa Rosa
Dixon
Napa
Confluence with Delta Cross Channel
Rio Vista Bridge
Vallejo
Benicia Bridge
Chipp's Island
Golden Gate
Bridge
San Francisco
Oakland

Late Fall Chinook Survival to Golden Gate 2007-2011 (5 years)

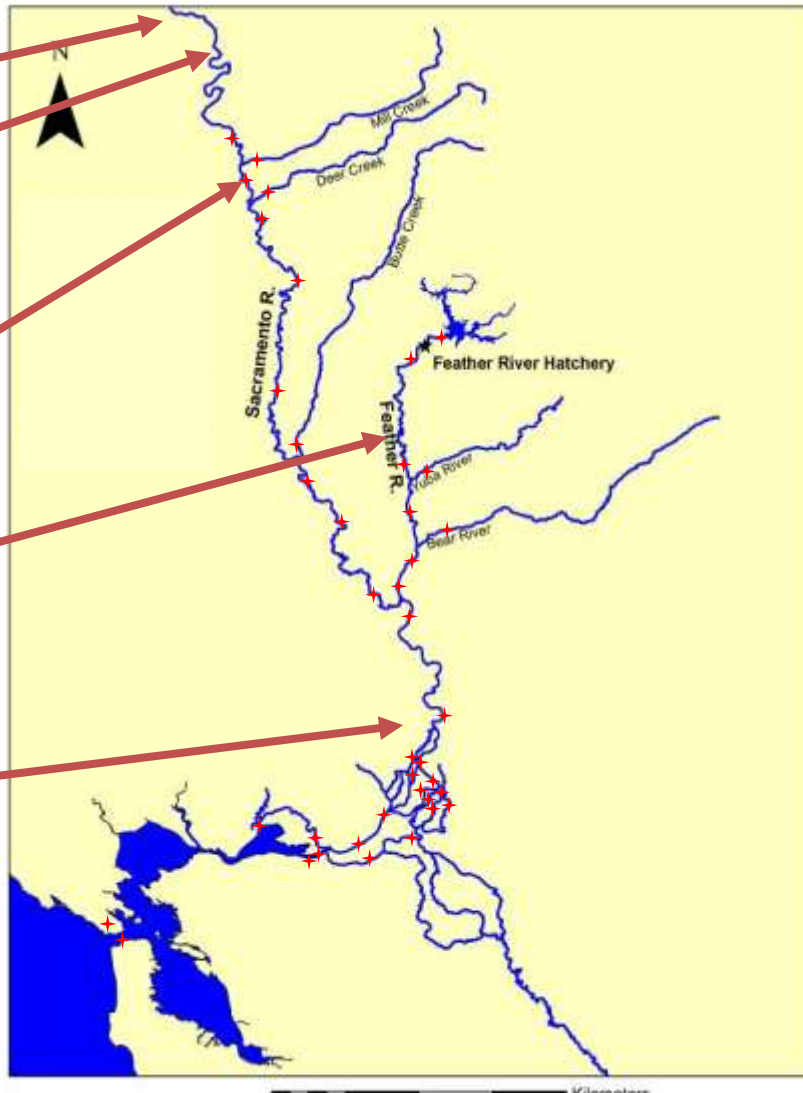


- Most effective life history strategy- SWIM FAST, get the hell out…
- This 84-97% mortality occurs in 2-3 weeks post hatchery release

Tagging Schedule 2012-2015

Tagging goals

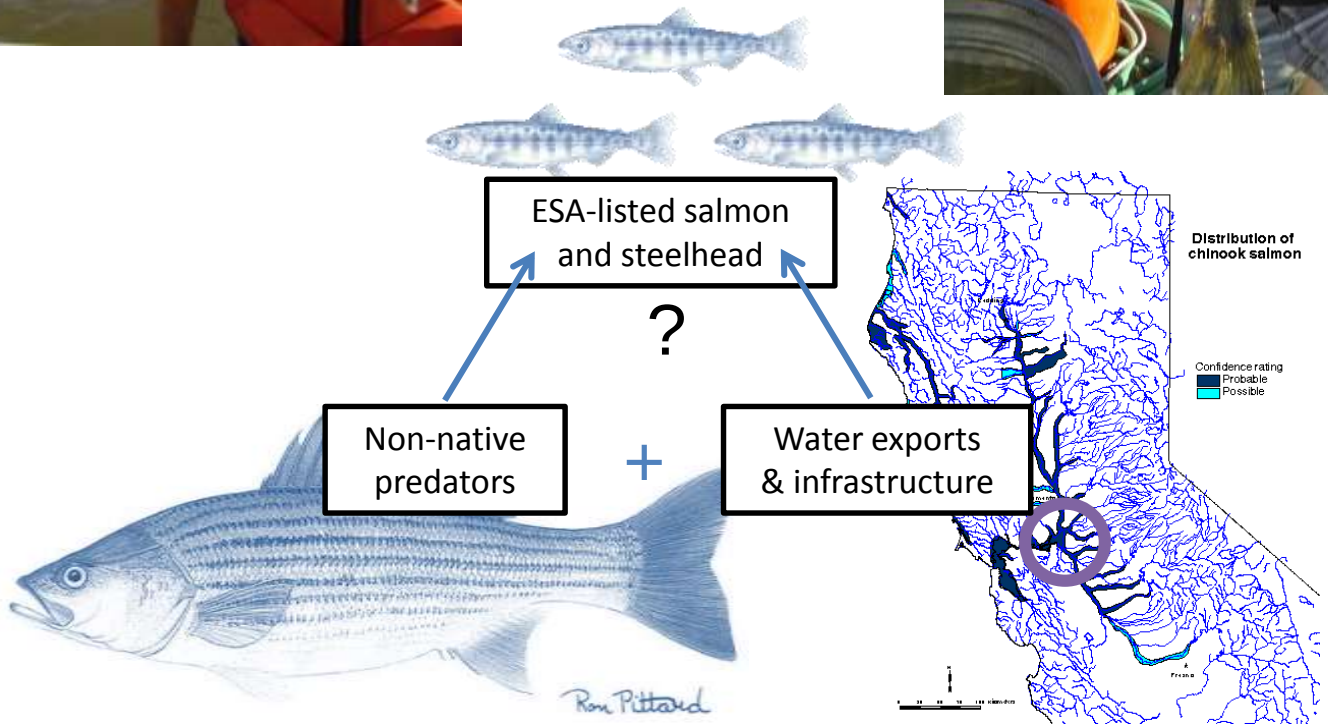
- Winter run- LSNFS
  - 300 Jan
- Fall run- CNFH
  - 150 x 2 early/late Apr
- Wild tagging from Deer and Mill Creek
  - 200 fish Nov-Apr
- Spring run from FRFH
  - 150 x2 Apr- upper/lower river
- Fall and Spring run releases into Delta
  - 100 f/100s x2 (repeat Perry et al 2010)



Comparative stock results

Run	Years	Survival	Transit time (days)	Area of Peak Mortality
Late Fall	2007-2011	3-16%	15-28	SF Bay
Fall	2012	3-5%	8-17	SF Bay
Spring	2012	<3%	9-17	Feather River
Winter	2013	4%	33-54	Middle Sac

Central Valley Predator Issues



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2014 Bassmaster Classic Credential Registration is NOW OPEN!
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NEWS

Tweet 38 Like 507

100 best bass lakes of 2013

Bassmaster Magazine's official list for 2013

By **James Hall, Bassmaster Magazine**

APR 24, 2013

Lists that rank the subjective can incite passionate response. Last year, I learned this the hard way when *Bassmaster* Magazine released its inaugural ranking of bass fisheries from across the nation. One reader thanked the Magazine for producing his lifetime bucket list, while another said it was the biggest waste of space he had ever seen. One reader said we ranked Bull Shoals way too low at 51; another said the lake didn't deserve to be on the list. The debates seemed endless and went on for months, which made me think that the concept of ranking

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- 100 lakes you MUST fish

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When VanDam gets into 'trebl
Wild Card field is set
Tips for fishing docks in any s
The forgotten single spin

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8. Lake Okeechobee, Florida
9. San Joaquin Delta, California
10. Toledo Bend Reservoir, Texas/Louisiana

NEWS Tweet 38 Like

100 best ba

Bassmaster

By Jam
Ma

learned
assmaster
its inaugural ranking
nes from across the nation.
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BASSMASTER 100 BEST BASS LAKES

RELATED STORIES

- 100 lakes you MUST fish

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Most Viewed | Most Commented

- When VanDam gets into 'trebl
- Wild Card field is set
- Tips for fishing docks in any s
- The forgotten single spin

Bass present for 130+ years, why a problem now?

- Constant introductions of Invasive Species
  - Asian Clams ***Corbicula fluminea***
    Potamocorbula amurensis,

  - Aquatic Plants
    - ***Egeria densa***

    - **Water Hyacinth**

Bass present for 130+ years, why a problem now?

Bass present for 130+ years, why a problem now?

Fishbio.com

Bass present for 130+ years, why a problem now?

California's Department of Boating and Waterways (DBW) $6.5 million every year

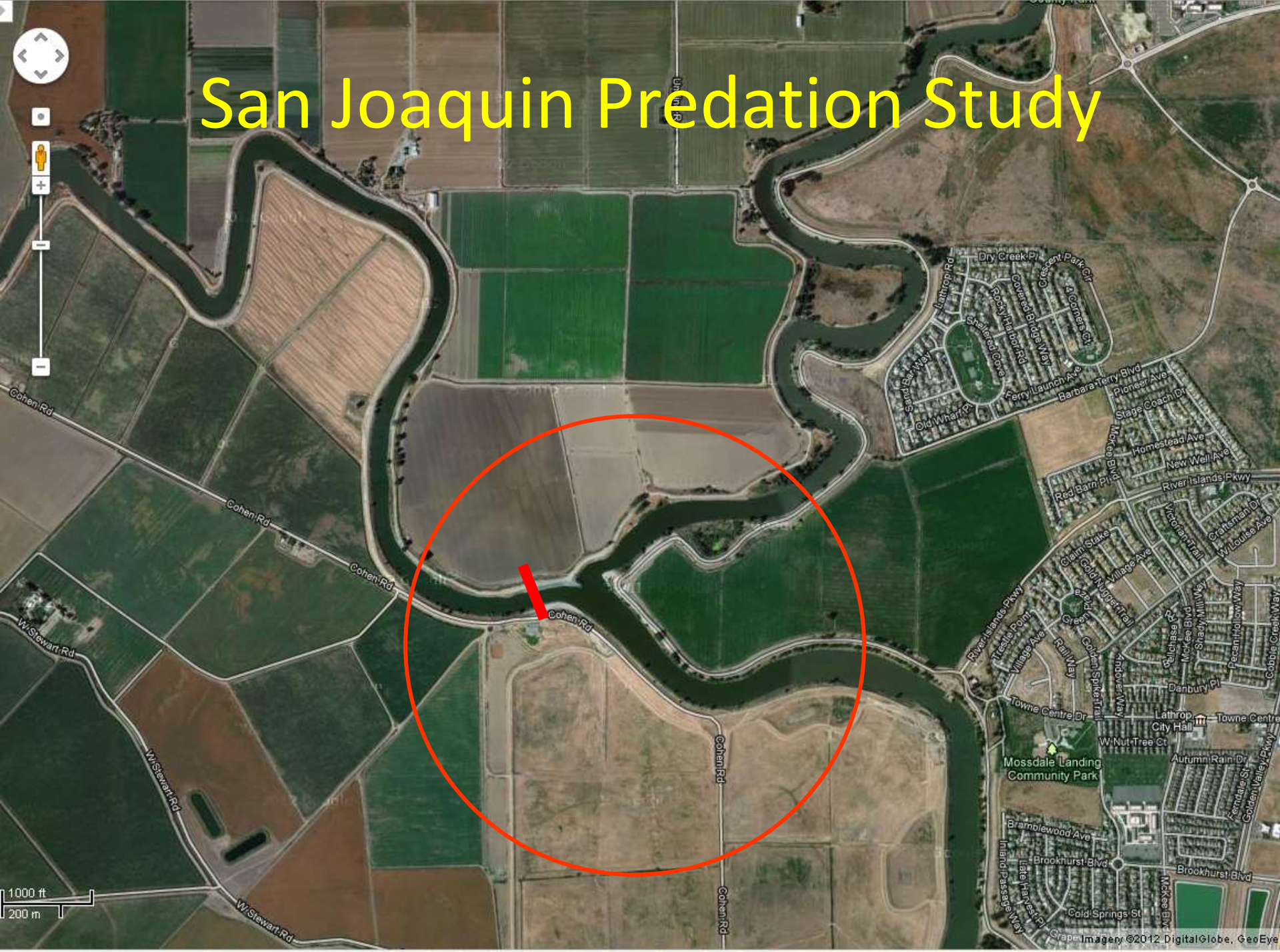
Removal Control Options:
Mechanical removal (89 Tons/acre/year) and requires specialized equipment for removal.

Chemical treatment, herbicides: glyphosate (Roundup) or 2,4-D (ingredient in Agent Orange)

Fishbio.com

Discovery Bay
Discovery Bay Country Club
4
Clifton Court Forebay
J4
Mountain House
2 mi
2 km
West Valley Mall
205
5

San Joaquin Predation Study



Head of Old River Fish Barrier
http://baydeltaoffice.water.ca.gov/sdb/tbp/web_pg/tempbar/HORB.html

San Joaquin predator study

(2014-2015)

1. Acoustic survey fish community (FRD AST)
2. Measure survival of 3100 tagged fish
3. Extensive predator removal
4. Measure predation rates (tethers)
5. Repeat 1-4 above (BACI design)

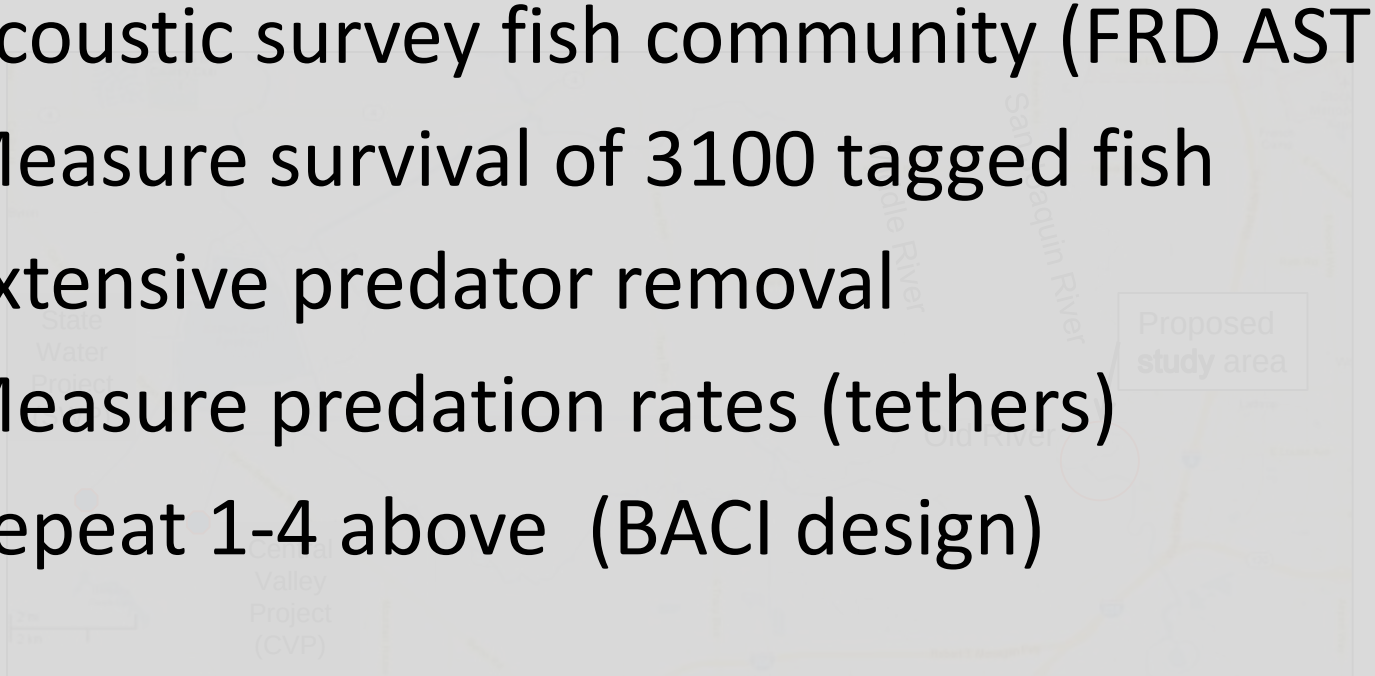
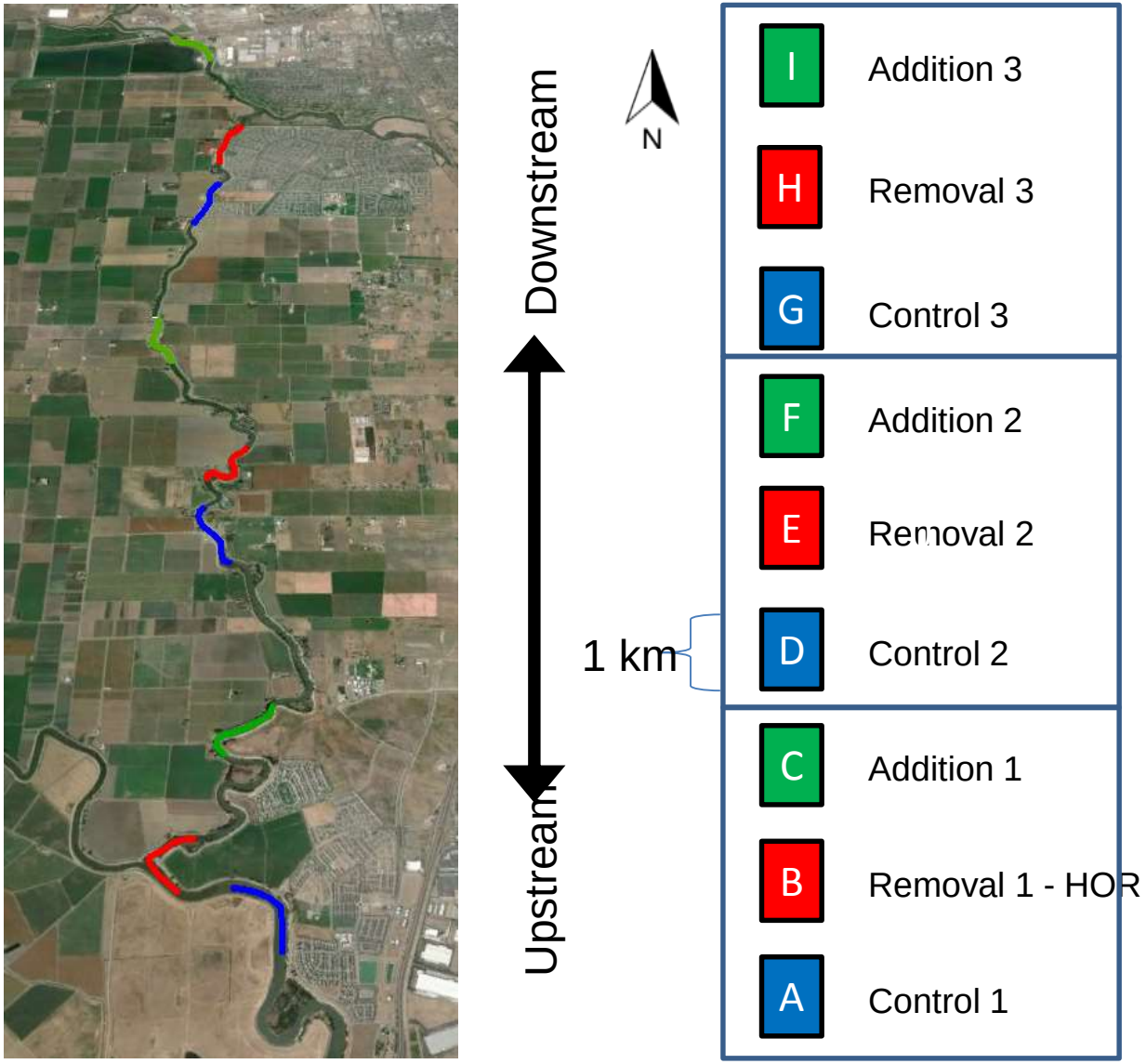
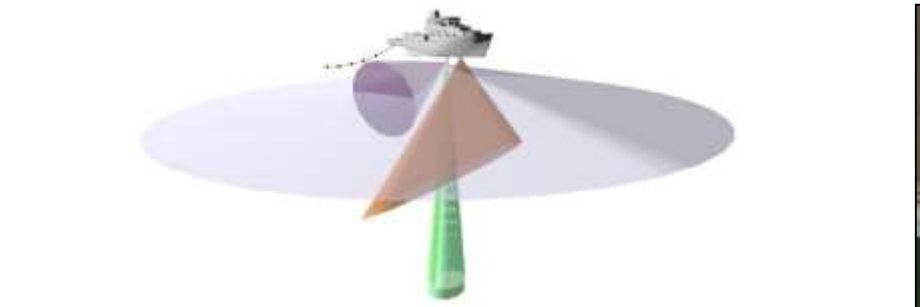


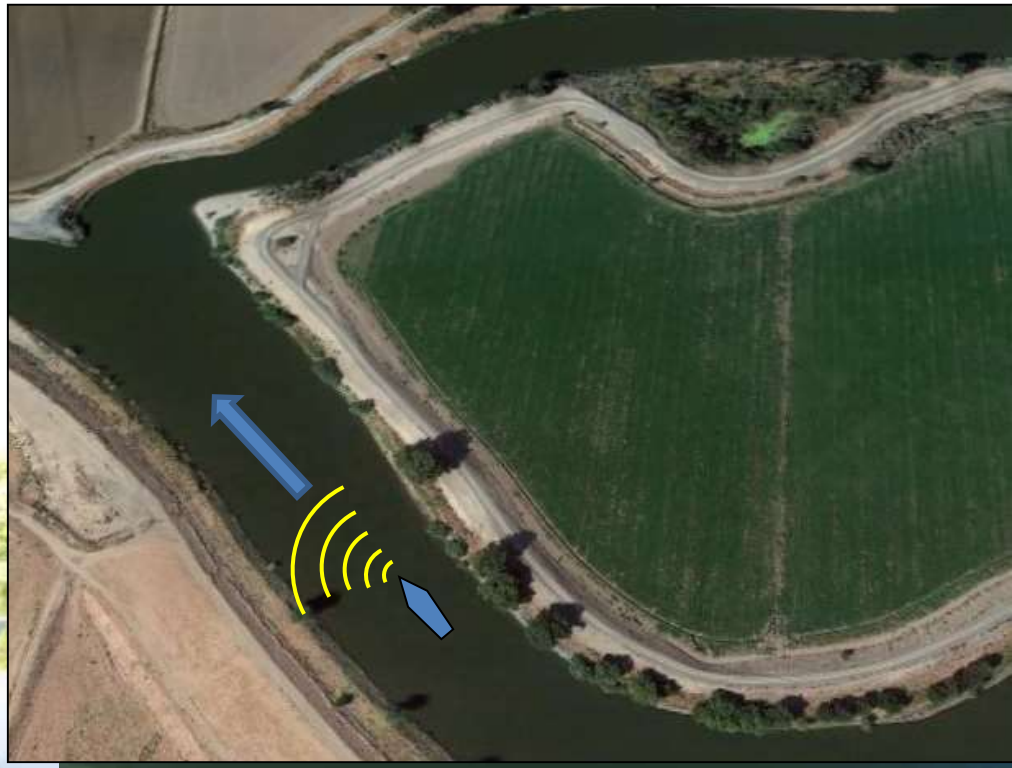
Figure 2. Study area location at the confluence of San Joaquin and Old Rivers, relative to State and Central Valley Water Projects

BACI Study design with replicates



Hydro-acoustic Sampling

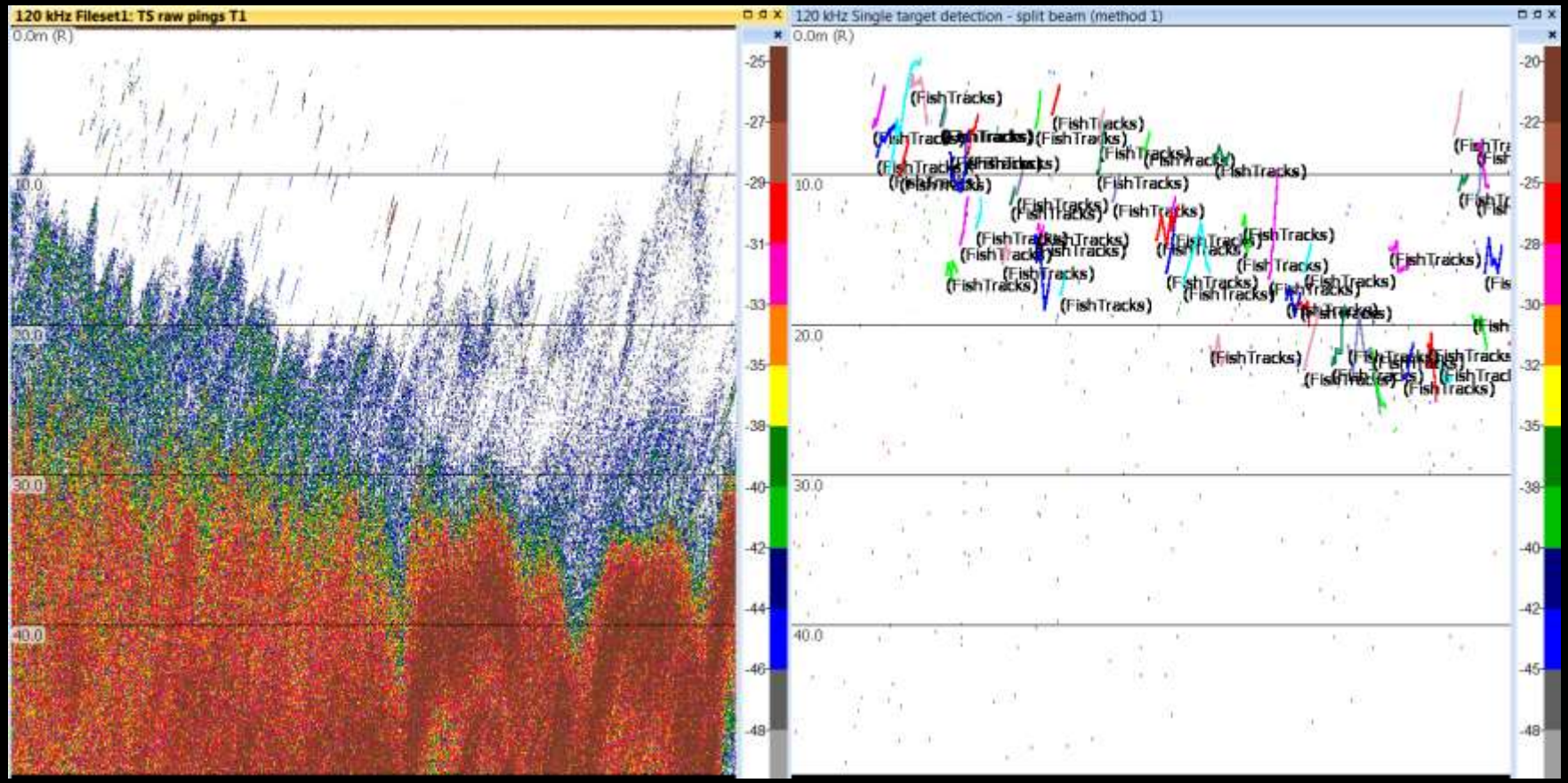




Multibeam Sonar High-res Bathymetry

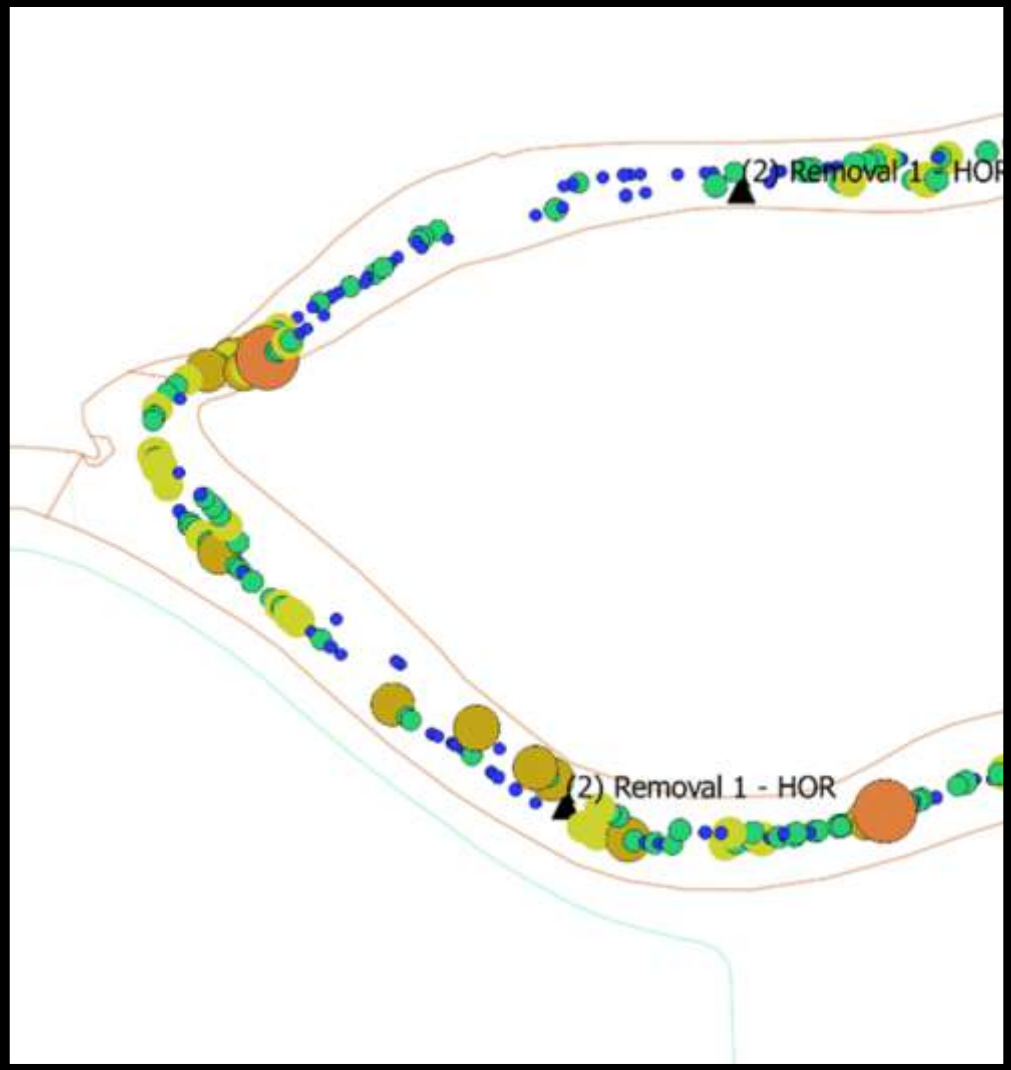
- 500 kHz Multibeam sonar
  - Kongsberg Mesotech M3
- Bathymetry point cloud
- Example from study reach #9

Fish detections



- EK60 echogram (left)
  - Horizontally mounted transducer
- Individual fish track detections (right)
- Example from March 24, 2014

Count of fish detections

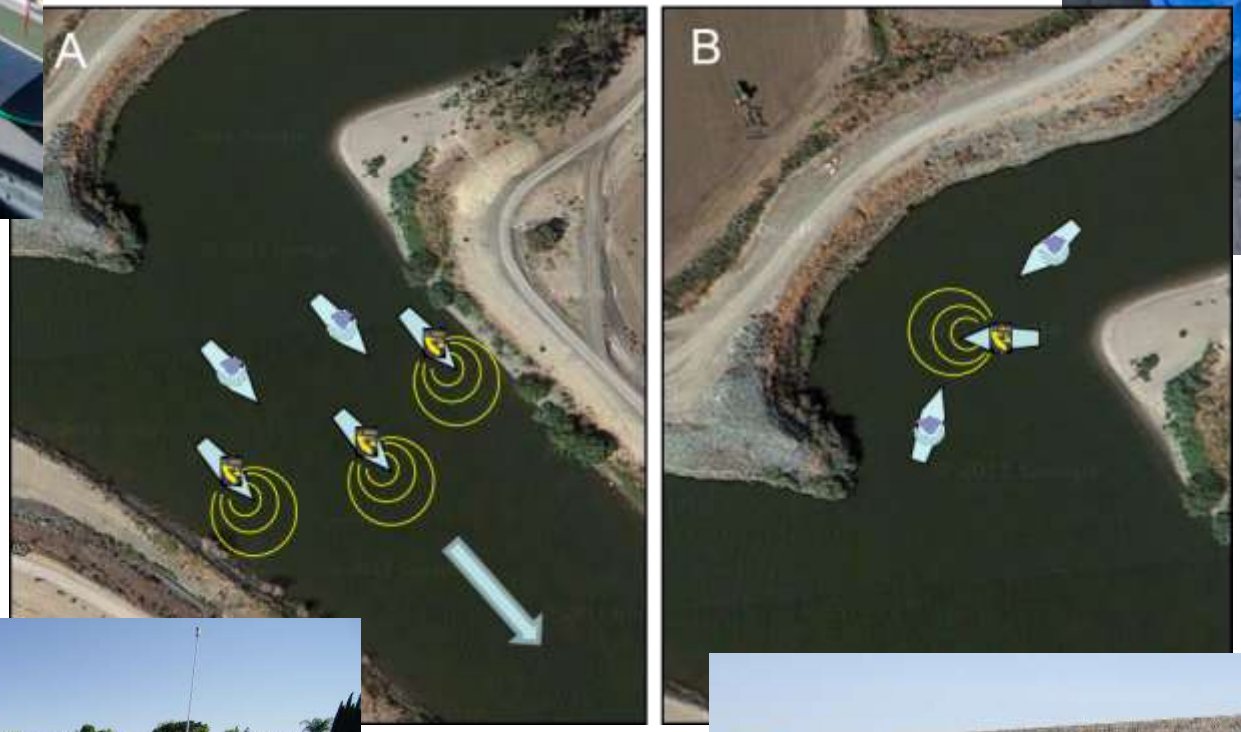


- ***Preliminary*** counts of fish detections
- Head of Old River study reach
- Data from March 2014.

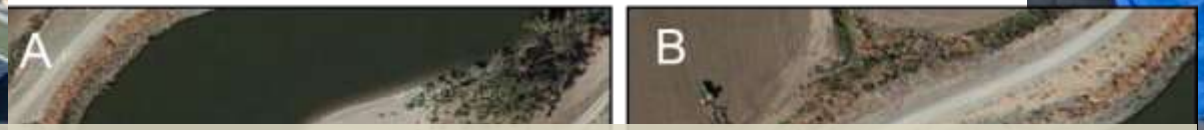
Legend

- 1-5
- 5-8
- 8-12
- 12-18
- 18-37
- 37-54

Electrofishing



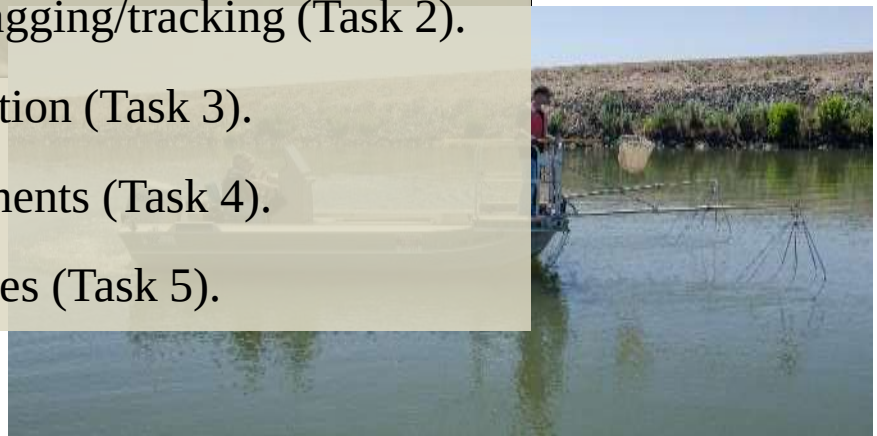
Electrofishing



Task 3 - Predator collection, identification, removals and additions (2014-2015)

Predators collected from mid-March through May to fulfill 5 objectives:

1. Determine species/community present relative to habitat types, flow/water quality conditions, season and for comparison with hydroacoustic data sets (Task 1).
2. Collect predators for acoustic tagging/tracking (Task 2).
3. For population depletion/relocation (Task 3).
4. In response to tethering experiments (Task 4).
5. Collect predators for diet samples (Task 5).



Predator Acoustic Tagging

Species	Tagged	Transported	Mean FL	Range FL
Largemouth bass	66	36	367	226-548
Striped bass	37	27	391	271-853
White catfish	29	19	282	240-365
Channel catfish	18	8	447	322-572

Objectives:

- Movement patterns- roving vs. resident
- Seasonal distributions (from larger array)
- Effectiveness of ‘relocation’

Baited Tether Experiments

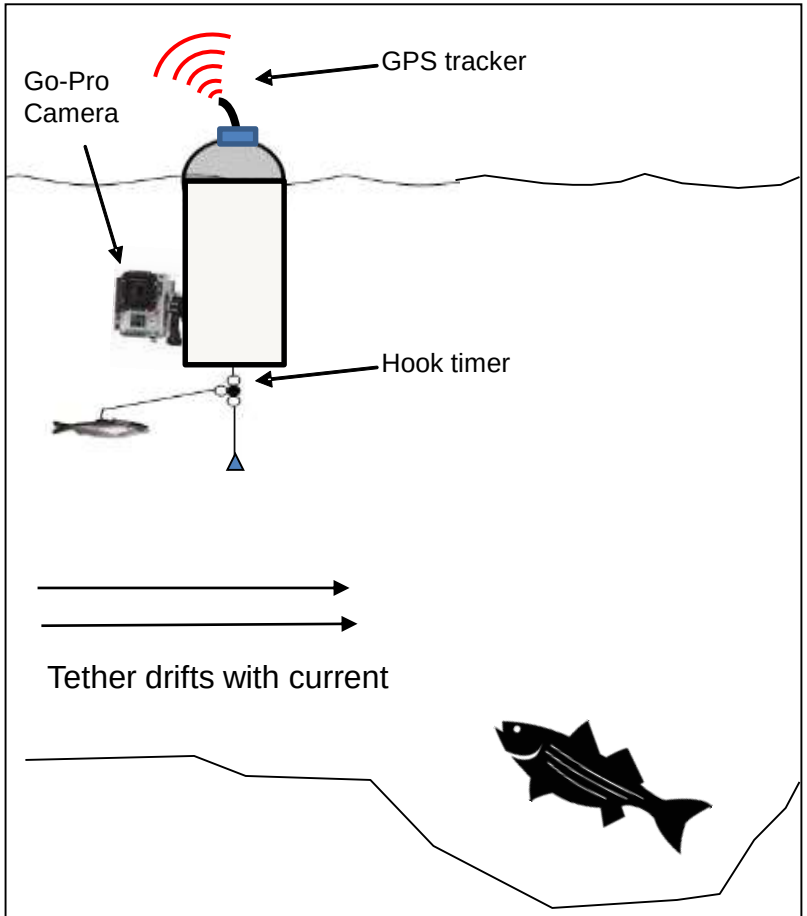


Figure 6. Schematic of proposed tether deployment method

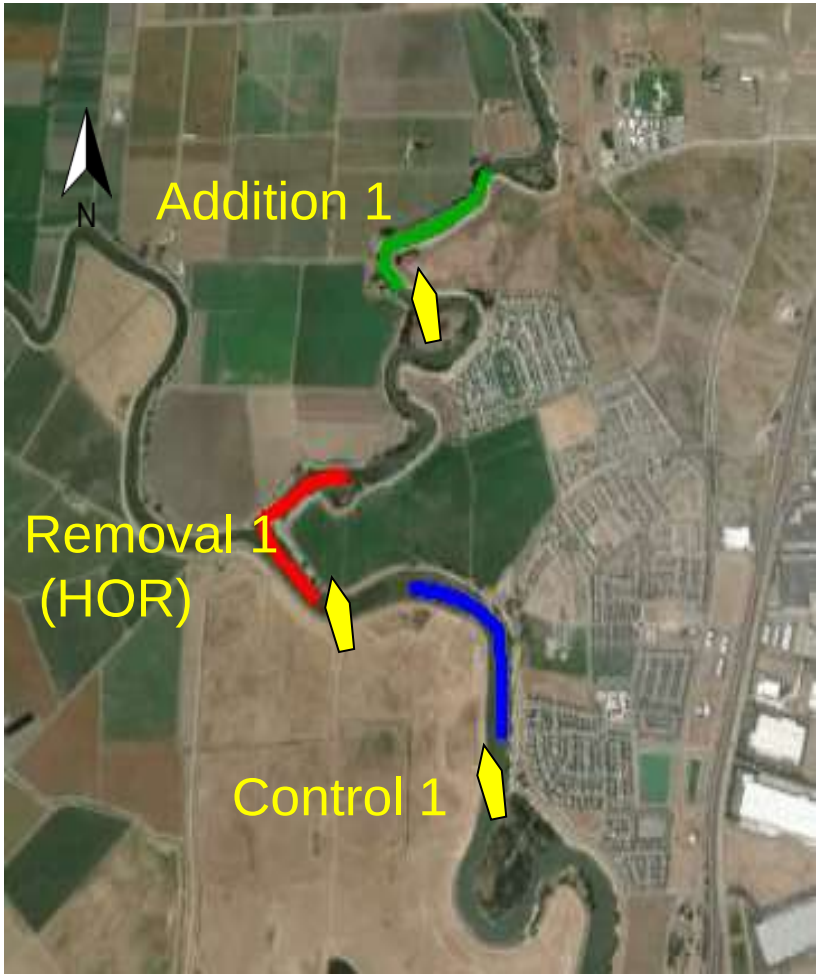
Tethering has inherent bias:

- restricted movement of smolts probably increases their susceptibility to predation.
- goal is NOT to prove/disprove predation, nor measure absolute rates
- (this is done by stomach DNA content and modeling of acoustic tagging survival)
- evaluate relative changes in predation relative to changing dynamics

Photo by M. Bond (UW)

Tether Deployment Footage

Tether deployment strategy

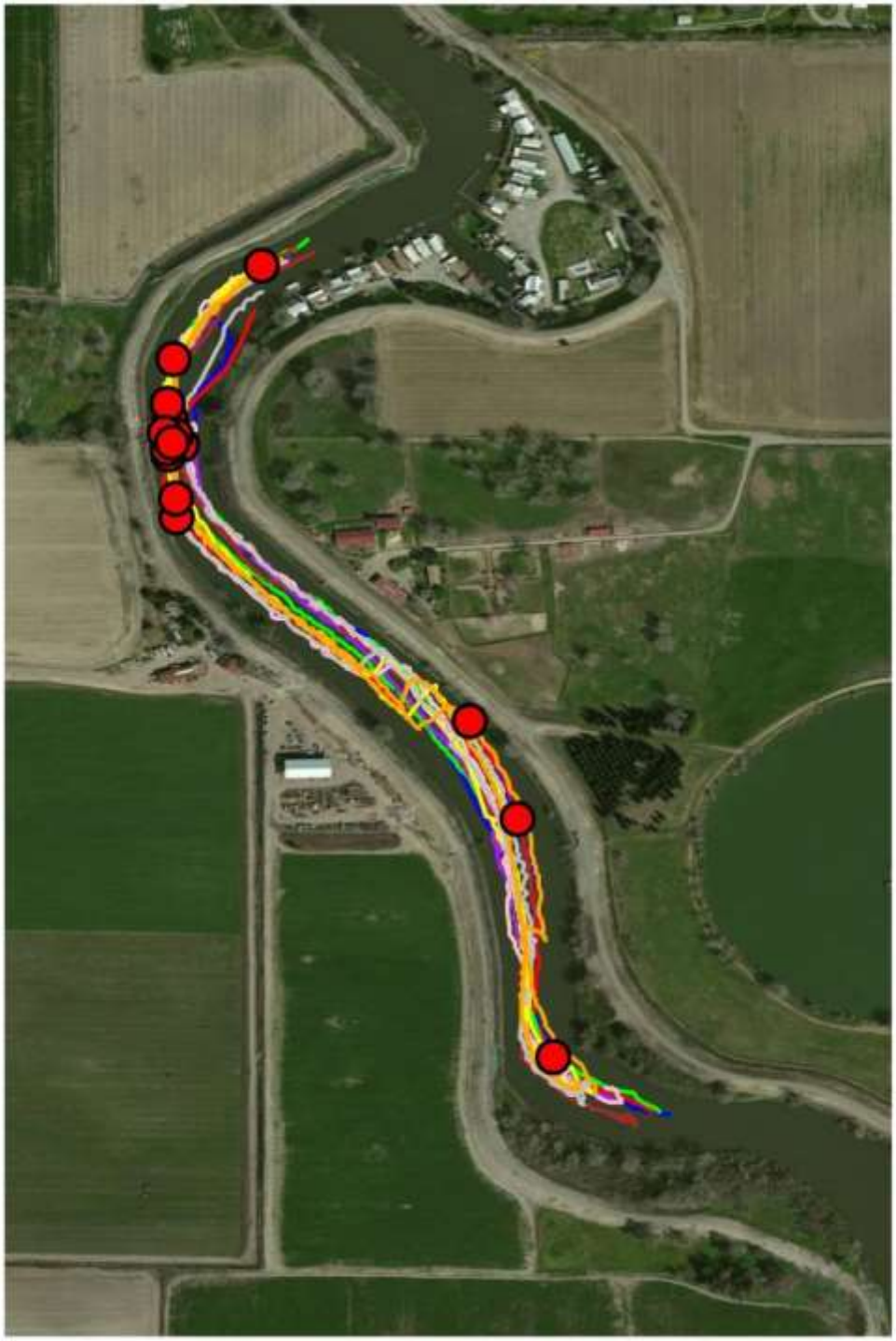


Downstream

Upstream

- Strong diel effect
  - Dawn/dusk peak
- Revised strategy
  - 3 boats –synchronized
  - Deploy 10 units, drift and repeat

Control 2
5/10/2014
Morning



The Predator Issue…..
Just how bad is it?

Loboschefsky, E., Benigno, G., Sommer, T., Rose, K., Ginn, T., Massoudieh, A., and Loge, F. 2012. Individual-level and Population-level Historical Prey Demand of San Francisco Estuary Striped Bass Using a Bioenergetics Model. San Francisco Estuary and Watershed Science **10**(1).

- Sacramento Bay/Delta populations of striped bass consume….

  ~25,000,000 KG of fish per year

The Predator Issue…..
Just how bad is it?

Loboschefsky, E., Benigno, G., Sommer, T., Rose, K., Ginn, T., M[illegible]dieh, A., and Loge, F. 2012. Individual-level and Population-level Historical Prey Demand of San Fr[illegible] Striped Bass Using a Bioenergetics Model. San Francisco Estuary and Watershed Scienc[illegible]

- Sacramento Bay/Delt[illegible] striped bass consume….

  ~25,000,000 KG of f[illegible]

5% survival

…of 12 million baby salmon

(600,000 left….)

the single largest Chinook release in CA
10,000,000 fish * 5g= 50,000 kg

50,000kg/25,000,000= ….0.2%
of striped bass annual
metabolic requirements

The envelope continued

- CA hatcheries release 50million fish (some years)…
- Mostly sub-yearling, some yearlings… ave 10g fish?

10g *50,000,000= 500,000kg hatchery salmonids

500,000/25,000,000 kg= 2%

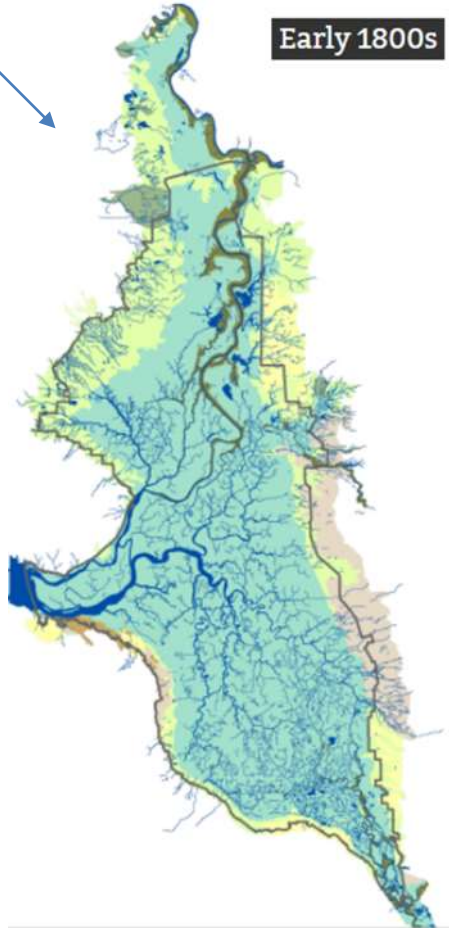
"Striped Bass are not a problem for salmon….
they rarely appear in their diet…"

Striped bass can eat every single juvenile salmon in the Sacramento/San Joaquin basin and they still wont be a significant part of striped bass diet…

Is predation THE problem?

Historically massive migratory bird corridor…

Not so many today…

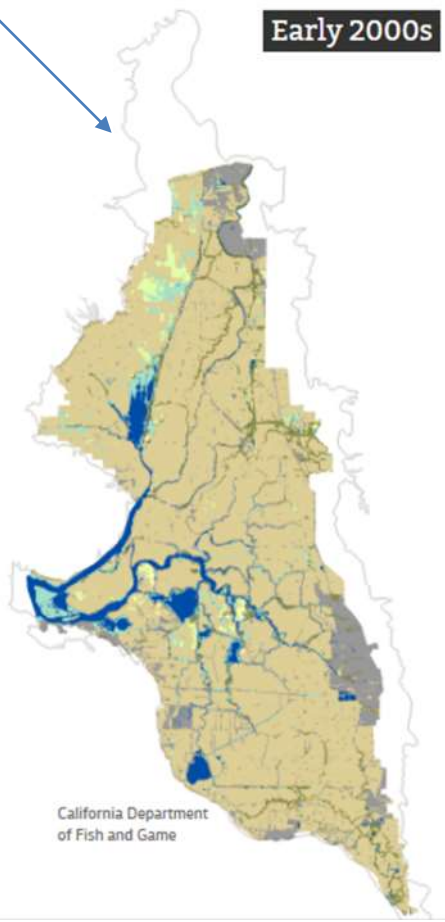


Compare the Delta Across Eras

Click on the habitat types below to see how the Delta's waterways and landscape have been changed.

- Show All
- Agriculture
- Urban
- Water
- Freshwater Wetland
- Willow Thicket
- Riparian Forest
- Seasonal Wetland
- Dune Scrub
- Grassland
- Oak Woodland

Note:
The outline on the map at left indicates the mutually mapped area. The outline on the map at right indicates the boundary of the SFEI-ASC study.

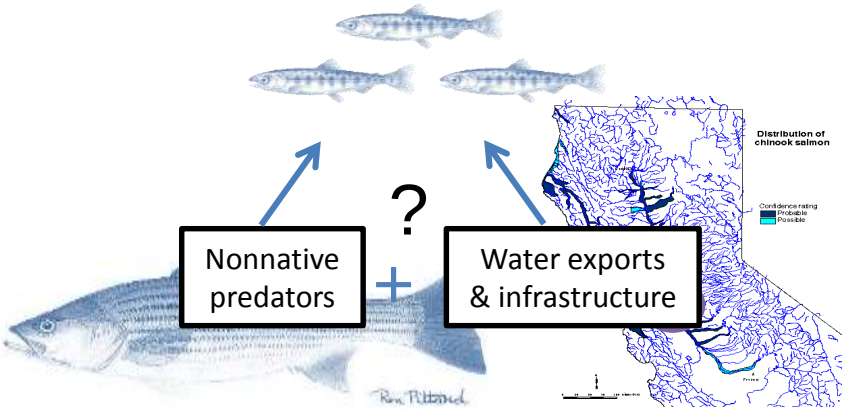


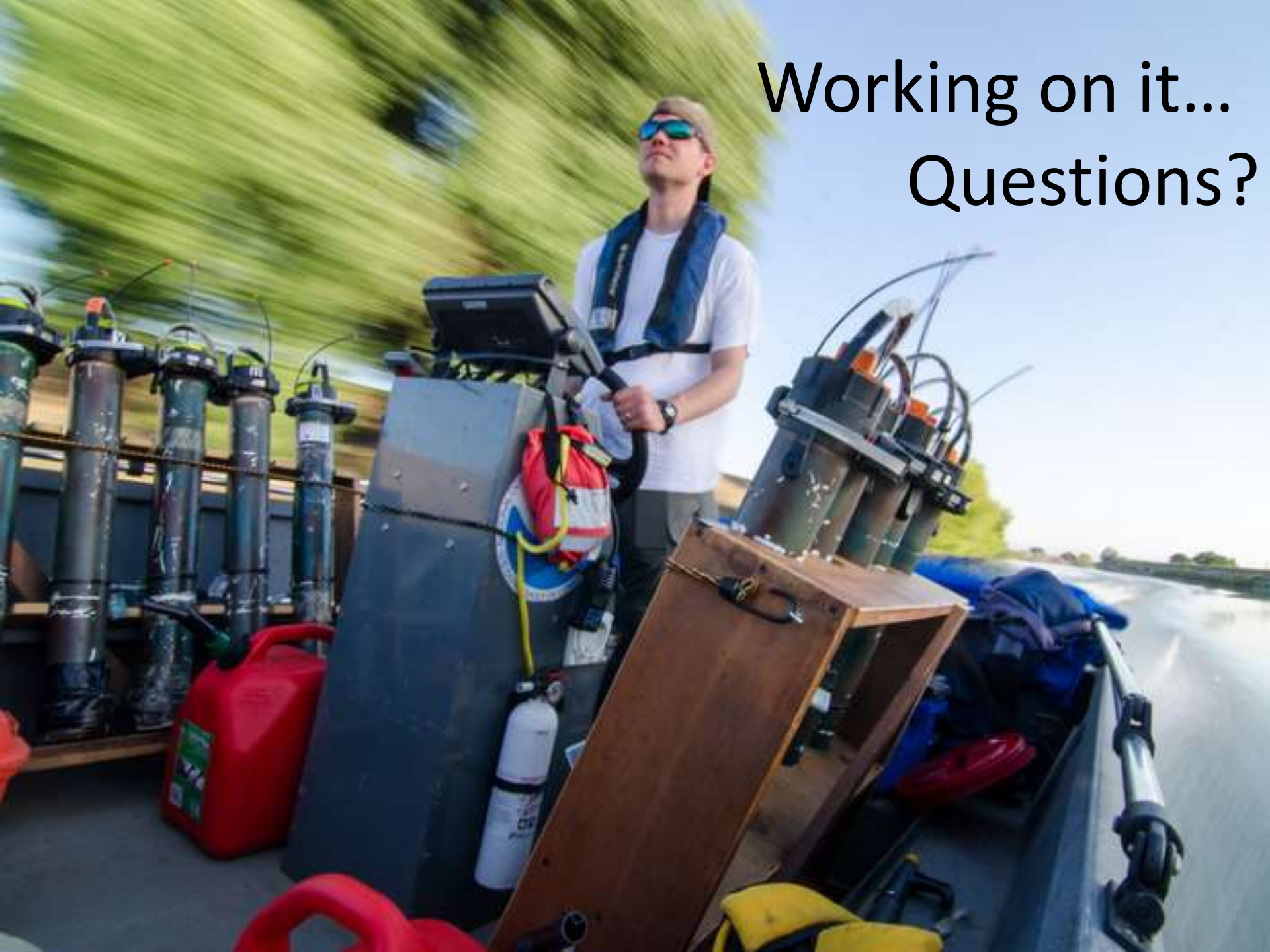
The Future…

- Problem remains complex- not just Bass….
- Combination of altered habitat, diversions, and predators.
- Cage experiments- WQ and disease
- All empirical data are feeding a large Salmon Life Cycle Model at FED (Lindley)
- Fish & Ag economics+ Human safety at risk

<u>NO WIN</u> Solutions

Requires NMFS input…..





Working on it…
Questions?